Convention on the Conservation of Migratory Species of Wild Animals

Secretariat provided by the United Nations Environment Programme

1st Meeting of the Task Force on Reconciling Selected Energy Sector Developments with Migratory Species Conservation

Cape Town, South Africa, 1-2 December 2016

ETF1/Inf.1

RENEWABLE ENERGY TECHNOLOGIES AND MIGRATORY SPECIES: GUIDELINES FOR SUSTAINABLE DEPLOYMENT

(As adopted by the 6th Session of the Meeting of the Parties to the Agreement on the Conservation of African-Eurasian Migratory Waterbirds/AEWA)

AGREEMENT ON THE CONSERVATION OF
AFRICAN-EURASIAN MIGRATORY WATERBIRDS

Doc: AEWA/MOP 6.37
Agenda item: 24
Original: English

Date: 23 August 2015

6th SESSION OF THE MEETING OF THE PARTIES

9-14 November 2015, Bonn, Germany

"Making flyway conservation happen"

DRAFT RENEWABLE ENERGY TECHNOLOGIES AND MIGRATORY SPECIES: GUIDELINES FOR SUSTAINABLE DEPLOYMENT

Background

Within the framework of a joint initiative between the Secretariats of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA), on behalf of the entire CMS Family; and the BirdLife International UNDP/GEF Migratory Soaring Birds project, *Guidelines for Sustainable Deployment of Renewable Energy Technologies with Respect to Migratory Species* have been compiled as a complement to the Review of the Occurrence and Magnitude of the Conflict between Migratory Animals of all Taxa and Renewable Energy Technologies Deployment (see document AEWA/MOP 6.38).

This document was produced under consultancy. It constitutes a version, which was presented at the CMS COP11 in November 2014 and endorsed by CMS Resolution 11.27, with some pertinent updates as per the latest round of consultations prior to the CMS COP11. This work has been contributing to the implementation of the task of the Technical Committee (TC) Working Group 8 on renewable energy and migratory waterbirds and the TC was consulted during the drafting of the Terms of Reference, as well as in the preparatory phase of these guidelines.

At its 12th meeting in March 2015, the TC signed off these guidelines for submission to the Standing Committee meeting and MOP6 while noting that this is the first version of the Guidelines which is aimed to be reviewed in consultation with IRENA, the UNEP/CMS Secretariat and BirdLife International so as to deliver a second version of the Guidelines to a future CMS COP and AEWA MOP. The Standing Committee approved the submission of the Guidelines to MOP6 at its 10th Meeting in July 2015.

The production of this document was made possible thanks to financial contributions from the Governments of Germany and Norway through the UNEP/CMS and UNEP/AEWA Secretariats, from BirdLife International through the UNDP/GEF Migratory Soaring Birds project.

Action requested from the Meeting of the Parties

The Meeting of the Parties is invited to review and approve these guidelines as Conservation Guidelines in the sense of Article IV of the Agreement (draft Resolution AEWA/MOP6 DR5 *Revision and Adoption of Conservation Guidelines*) while noting that these Guidelines are to be reviewed in consultation with IRENA, the UNEP/CMS Secretariat and BirdLife International so as to deliver a second version of the Guidelines to a future AEWA MOP.

Renewable Energy Technologies and Migratory Species: Guidelines for sustainable deployment

J. van der Winden
F. van Vliet
A. Patterson
B. Lane
(editors)

Final Draft

Renewable Energy Technologies and Migratory Species: Guidelines for sustainable deployment

J. van der Winden[1]
F. van Vliet[1]
A. Patterson[2]
B. Lane[3]
(editors)

1. Bureau Waardenburg
2. ESS Group
3. Brett Lane & Associates

Bureau Waardenburg bv
Consultants for environment & ecology

Boere
Conservation Consultancy

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management

ess group

commissioned by the Secretariats of the Convention on Migratory Species and the African-Eurasian Waterbird Agreement on behalf of the CMS Family and BirdLife International through the UNDP/GEF/BirdLife Migratory Soaring Birds Project

22 February 2015 (modified 01 June 2015)

Status:	Final draft
Date of publication:	22 February 2015
Title:	Renewable Energy Technologies and Migratory Species: Guidelines for sustainable deployment.
Editors:	J. van der Winden, F. van Vliet;, A. Patterson, B. Lane
Number of pages incl. appendices:	100
Project nr:	13-107
Project manager:	drs. J. van der Winden.
Signed for publication:	Teamleader Bird Ecology drs. T. Boudewijn
Initials:	

The Quality Management System of Bureau Waardenburg bv has been certified by CERTIKED according to ISO 9001:2008.

Summary

In order to plan future renewable energy technologies (RET) in a sustainable way, impacts on migrating species should be minimised. As RET proceed rapidly worldwide, impacts might be serious but on the other hand knowledge on minimising these impacts increases as well. CMS, AEWA and BirdLife International realised this and started a cooperative initiative to present an overview of current knowledge (Van der Winden *et al*. 2015) to be used in minimising impacts on migratory species.

This guidelines report provides expert guidance on minimising the impacts of RET on migratory species. This includes steps in the planning, design and policy process as well as mitigating and avoiding possible impacts by renewable energy technologies. The types of renewable energy and site specific situations make it impossible to provide straightforward guidelines ensuring sustainable planning in an easy way. This means that procedures, policy as well as mitigation techniques should be integrated in the planning process to make it most effectively. This document combines existing guidelines and examples of good practices related to six types of renewable energy technology, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy.

These guidelines present the current state of the art. Any guidelines for effective deployment of renewable energy technologies in a way that is sensitive to migratory species must continuously evolve and be informed by lessons learned from increased deployment of renewables and making use of the best tools and practices available.

Many impacts are essentially related to habitat loss in the construction phase and the impacts are not specific for RET but result from any infrastructural development. These guidelines basically focus on the operational phase unless impacts are specific for RET in the construction phase.

Many impacts are related to the scale of the development. This means that in the guidelines document attention is paid to the scale of the process and to cumulative impacts of worldwide scattered small projects. This implies strategic planning at multiple level in conjunction with site specific impact assessments and mitigation strategies.

General guidance on strategic level

*National or sub-national plans, programmes and policies for RET should be subject to a Strategic Environmental Assessment (**SEA**), thereby taking into account migratory species.* Favoured areas for potential RET development should be identified and prioritised in relation to migratory species over a broad geographical area thereby taking into account the impacts, including cumulative impacts, of RET developments on migratory species effectively. This requires that countries have introduced legal or other provisions to formalize SEA as a planning requirement at national or sub-national level.

Modelling, GIS and Sensitivity mapping tools should be used to identify high-risk areas for migratory species. IRENA's Global Atlas, the Critical Site Network Tool and the BirdLife's Soaring Bird Sensitivity Map provide helpful instruments that combine information about migratory pathways, important staging sites and sites for identification and assessment of

potential renewable energy deployment locations. The IRENA Global Atlas also provides a platform for bringing all of these multiple tools together to inform planning for deployment of renewables that is sensitive to migratory species.

General guidelines on project level

Identify impacts of RET on migratory species on project level At project level, potential impacts of specific RET development projects on migratory species and measures should be identified to avoid, mitigate or compensate these impacts by carrying out an Environmental Impact Assessment (**EIA**). This requires that countries establish a well founded legislative basis for EIA, with specific requirements and prescribed responsibilities and that the EIA process meets internationally accepted requirements and standards of practice. The EIA process should include an adaptive management strategy with continuous monitoring and scientific evaluation to reduce impact uncertainties and improve mitigation measures over time.

Adopt a mitigation hierarchy of avoidance, mitigation, or compensation when dealing with potential negative impacts of RET projects and migratory species. When impacts on migratory species are likely or uncertain, the EIA should assess whether impacts on migratory species of the RET development and deployment can be avoided by siting, design, process, technology, route alternatives and 'no go' options. Many impacts can be avoided when considered during the siting and design phase. Especially, appropriate **siting** is critically important to avoid impacts. This goes for all forms of renewable energy developments. If it is not possible to avoid negative impacts, opportunities should be sought to reduce the impacts by mitigation measures. If mitigation is not possible, compensation may be appropriate.

Apart from general guiding principles related to siting and planning, a number of guidelines that apply especially to specific RET have been identified and are highlighted below. The table at the end of this summary chapter gives an overview of references to existing guidelines for the different RETs.

Bioenergy

Habitat loss and degradation are the main impacts of bioenergy technology on migratory species. Depending on the scale of the development, these impacts can be high. Apart from proper siting and planning strategies the following mitigation can be implemented:

- Appropriate choice of biomass feedstocks for energy use.
- Resource efficient use of biomass.
- Sustainable land and forestry management, including planting strategies, the timing and method of harvesting and choice of crops.

Geothemal

Geothermal energy technologies generally present relatively low impact on migrating species as compared to the development of other forms of energy, because of the relatively small overall footprint of geothermal energy conversion equipment and the relatively low water demand. The following mitigation can be implemented:

- Proper design of pipelines to avoid blocking of migration routes.

- Directional drilling techniques to minimize habitat loss.
- Proper wastewater disposal.
- Containment of chemical fluid spills.

Hydro energy

Hydropower energy technologies can have serious impacts on migratory species populations. Apart from proper siting and planning strategies the following mitigation can be implemented:

Hydrological regimes

- Maintaining river flow rates at levels needed to maintain the ecological function of the river and its associated habitats.
- Increase flow rates at fish passageway entry points to deter downstream fish passage through turbines and to encourage downward migration.
- Reservoir management that considers the requirements of any migratory species that utilize the habitats created by the reservoir (*e.g.* seasonal passage of fish or waterbirds).
- The judicious use of weirs, designed not to obstruct fish passage, but to create areas of permanent water in rivers affected by reduced flows from the operation of hydropower dams, thereby creating refuge habitat at critical times of year or during drought for migratory and other aquatic species.

Fish migration and river navigation –

- Installation of artificial fish passageways or fish ladders to allow passage of migratory fish species past dams.
- Installation of measures to attract and direct fish away from the intake to hydro power stations (acoustic type, mercury lamp, sodium lamp).
- Improvements in turbine, spillway, and over flow design have proven to be highly successful in minimizing mortality in and injury to fish and other aquatic organism mortality and injury.

Water quality - The following are to be implemented to improve water quality in reservoirs and downstream areas.

- Temperature control considering the growth of fish by installing selective water intake facilities.
- Reduction in water turbidity by selecting the operation of dams and constructing bypass tunnels.

Reservoir impoundment - The measures below can mitigate impacts relating to impoundment of reservoirs.

- Reductions in the scale of regulating reservoir levels and preservation of wetlands by maintaining appropriate water levels in reservoirs.

Ocean

The environmental impact of wave and tidal energy is rather unknown, since these two energy sources are in an initial phase. Main impacts of ocean energy on migratory species mainly are mortality, barrier effects and habitat degradation. The following specific measures to mitigate these impacts can be implemented:

- Use noise-deflecting devices around the work site during high-decibel generating phases of construction to avoid physiological impacts to marine mammals and sea turtles.
- Undersea cables within the ocean energy development array and at the landfall connection should be buried to depths within the sediment that will minimize or eliminate the impacts from EMF to sea turtles and marine mammals.
- Minimize the use of slack or loose tether and anchor lines to reduce entanglement risk to species.
- Use observers on board vessels to inform temporary cessation of construction, maintenance, and decommissioning activities with the aim of avoiding disturbance to marine species in the work area, including sea turtles and marine mammals.
- For tidal energy in estuaries: see above under 'Ocean energy'- Hydrological regimes.

SOLAR

Both PSV and CSP can result in habitat loss of migratory species**.** CSP has an additional mortality risk because of the associated central receiver tower, standby focal points and heliostats. The impacts are currently local as the scale of this development is not large and impacts on natural habitats for migratory species worldwide are not yet significant. Apart from proper planning strategies to minimise loss of important habitat for migratory species by CSP and PV, the following mitigation can be implemented specific for CSP :

- Decrease the number of evaporation ponds or use alternative types of solar energy technology that do not use evaporation ponds. If evaporation ponds are required based on the type of solar facility, those ponds should be fenced and netted when possible.
- Use alternative types of solar energy technology such as parabolic troughs, dish engines, and photovoltaic systems instead of using a central tower facility.
- Use fencing, netting and wire grids to ensure evaporation ponds are not accessible to birds and other fauna. This is to reduce the possibility of a) attraction b) drowning c) poisoning.
- Use avian deterrence techniques, including: facility habitat management; prey control; anti-perching technology; nest-proofing; netting or other enclosures; scaring or chasing through the use of trained dogs or raptors; and radar and long-range focused bio-acoustic or visual deterrence.
- When using a central tower solar facility, the occurrence and intensity of standby points should be kept to a minimum to decrease the occurrence of burning mortality to birds.
- Avoid surface water or groundwater withdrawals that affect sensitive habitats and habitats occupied by threatened or migratory species. The capability of local surface

water or groundwater supplies to provide adequate water for cooling, if required, should be considered early in project siting and design.
- Locate tall structures to avoid structures in important flight paths of birds and bats.

Wind energy

The impacts are currently locally serious as the scale of this development is increasing and impacts on natural habitats for migratory species worldwide might be significant. Apart from proper planning strategies the following mitigation can be implemented:

Design

- Establish larger space in between turbines to lower the collision rate of birds and the barrier effects for local foraging and breeding birds.
- To avoid barrier effects, long lines of turbines should be placed parallel to the main migration/flight route.
- Choose larger turbines to lower the to lower the collision rate of local birds and disturbing effects on ground-breeding birds.
- Use solid turbine towers instead of lattice constructions to avoid perching opportunities for birds of prey.

Construction and decommissioning

- Measures to avoid or reduce the impacts of pile driving on marine mammals, including the use of acoustic deterrent devices, the use of ramp up procedures, and limiting installation to periods with low marine mammal abundance.
- Identifying other technical possibilities to install wind turbines (e.g. alternative constructions such as tripod, jacket or gravity foundations, floating or platforms and/or other methods than pile driving such as installation by a water jet or drilling).

Operation

- Temporary shutdown of turbines in high-risk periods, such as peaks in migration activity or foraging flights or situations with strong winds (from a specific direction), to reduce bird mortality.
- Targeted curtailment i.e. stopping or slowing down the rotor blades of a wind turbine during periods of high bat activity to limit bat mortality.
- Modification of turbines and foundations to reduce noise emission at relevant frequencies in the operation phase, to limit the impact of noise emission on marine mammals

Recommendations

The following recommendations for actions and research related to minimizing the impacts of renewable energy technology developments on migratory species can be made:

1. **Global assessment of RET development in relation to migratory species**. The nature of transboundary movements of migratory animals within their migration range requires that strategic planning of RET development have an *international* dimension. It is highly recommended that RET development is assessed on international scale, thereby taking into account important areas for migratory species populations and

cumulative impacts of developments. For this, international co-operation between developers, policymakers and other stakeholders is needed.

2. **Further development of sensitivity mapping tools.** It is highly recommended that sensitivity mapping is further developed on an international and national scale.
3. **Definition of impact criteria.** Develop, propose and implement internationally accepted ecologically based impact criteria for the assessment of the effects and also cumulative effects of renewable energy technologies at migratory species population levels.
4. **Install a multi-stakeholder task force** to facilitate the process of reconciling energy sector developments with the conservation of migratory species. The task force should promote that existing decisions and guidelines are implemented, any necessary new guidelines and action plans are elaborated, suitable responses to specific problems are recommended and put in place and gaps in knowledge are filled.
5. **Monitoring the environmental impacts during the life cycle of existing RET** is needed to learn more about the impacts on migratory species. For all RET developments the long-term and population-level consequences of large-scale deployments need further research.
6. **Promote publication of results of evaluation of mitigation** measures (post construction monitoring). The information can be used for improvement of mitigation techniques for other renewable energy projects in future.
7. **Increased and focused research on migratory pathways.** For all RET the primary gap in knowledge of (potential) impacts of RET development and migratory species lie in the detailed understanding of important areas for migratory species. Many species' migration routes and habitat use patterns remain understudied and require further research.
8. **Increased and focused research on effective mitigation measures.** More research is needed on new innovative measures to avoid and/or mitigate impacts of RET on migratory species and the effectiveness of measures.
9. **In this report many gaps in knowledge are recognised.** Addressing these will be important. For instance the development of tidal barrages needs proper studies as the impacts might be serious.

Increased knowledge on impacts of RET on migratory species and effective mitigation measures will better inform decision making in support of the prospective accelerated deployment of renewable energy done in a way that is reconcilable to the protection of migratory species. At the project level the improved knowledge should help streamline environmental impact assessments of renewable energy projects.

Summary table of guidelines

	Planning and pre-construction assessment	Mitigation and Compensation	Policy and guidelines	Other (effects, monitoring, etc.)
General	1, 2, 3, 4, 10, 11, 13	9, 45, 46	3, 4, 5, 8, 10, 11, 12, 13, 14	5, 14, 25, 79, 84
Associated infrastructure	20, 21	15, 16, 17, 18, 19, 20, 22, 23, 24	7, 17, 19, 20, 21, 23	25
Bioenergy	27, 28, 29, 30		28, 29, 30, 31	26, 27, 28
Geothermal energy	4, 32		4, 32	
Hydropower	4, 33, 35, 36	38, 45, 46	4, 34, 35, 36, 37, 38, 39, 40, 42, 43, 44	41
Ocean energy	48	45, 46	47, 49, 50	50, 82
Solar energy	4, 52	51	4, 52	51
Wind energy	3, 4, 55, 57, 59, 60, 62, 64, 67, 68, 69, 71, 77, 85, 88, 89, 92, 93	53, 54, 56, 63, 76, 78, 81, 83, 90, 98	3, 4, 6, 55, 60, 61, 62, 63, 64, 66, 70, 72, 74, 77, 80, 86, 87, 88, 89, 91, 92, 93, 94, 95, 96, 97, 99	6, 57, 58, 61, 65, 67, 68, 69, 73, 75, 81, 82, 85, 98

1. BirdLife International 2014 The MSB Sensitivity Mapping http://migratorysoaringbirds.undp.birdlife.org/en/sensitivity-map
2. BirdLife Europe, 2011. Meeting Europe's Renewable Energy Targets in Harmony with Nature (eds. Scrase I. and Gove B.). The RSPB, Sandy, UK.
3. Birdlife International n.d. Birds and Wind Farms within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Wind Energy Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents
4. Burger, J. & M. Gochfeld,, 2012. A Conceptual Framework Evaluating Ecological Footprints and Monitoring Renewable Energy: Wind, Solar, Hydro, and Geothermal. Energy and Power Engineering, Vol. 4 No. 4, 2012, pp. 303-314. doi: 10.4236/epe.2012.44040.
5. Convention on Biological Diversity (CBD) 2014.Identification, monitoring, indicators and assessments. COP 6 Decision VI/7. http://www.cbd.int/decision/cop/?id=7181
6. Gove, B., R.H.W. Langston, A. McCluskie, J.D. Pullan & I. Scrase. Wind farms and birds: an updated analysis of the effects of wind farms on birds, and best practice guidance on integrated planning and impact assessment. RSPB/BirdLife in the UK. Technical document T-PVS/Inf(2013)15 to Bern Convention Bureau Meeting, Strasbourg, 17 September 2013.
7. Gyimesi A. & Prinsen H.A.M., in prep. Guidance on appropriate means of impact assessment of electricity power grids on migratory soaring birds in the Rift Valley / Red Sea Flyway. Bureau Waardenburg, Culemborg.
8. IUCN 2014. IUCN Red List of Threatened Species. http://www.iucnredlist.org
9. Rajvanshi, A. 2008. Mitigation and compensation in environmental assessment. Chapter 17 in T.B Fischer, P. Gazzola, U. Jha-Thakur, I. Belcakova, and R, Aschemann, eds. Environmental Assessment Lecturers' Handbook, EC Penta Erasmus Mundus Project, February 2008. http://www.twoeam-eu.net/handbook/05.pdf
10. Ramsar Convention on Wetlands 2008. Resolution X.17 Environmental Impact Assessment and Strategic Environmental Assessment: Updated Scientific and Technical Guidance. www.ramsar.org/pdf/res/key_res_x_17_e.pdf
11. Slootweg R., A. Kolhoff, R. Verheem, R. Hoft 2006. Biodiversity in EIA and SEA — background document to CBD decision VIII/28: guidelines on biodiversity-inclusive impact assessment. The Netherlands: Commission for Environmental Assessment.

12. The OECD DAC Network on Environment and Development Co-operation (ENVIRONET) SEA Guidance and Advisory Notes (all available at the SEA Task Team website. http://www.seataskteam.net/guidance.php
13. The OECD DAC Guidance on SEA: Applying Strategic Environmental Assessment. Good Practice Guidance for Development Co-operation, OECD, Paris. http://www.oecd.org/dac/environment-development /37353858.pdf
14. United Nations 2014. The Integrated Biodiversity Assessment Tool (IBAT). https://www.ibatforbusiness.org/login and http://business.un.org/en/documents/8112 and http://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/090/original/IBAToverview.pdf?1398440561
15. APLIC (Avian Power Line Interaction Committee), 2006. Suggested practices for avian protection on power lines: The state of the art in 2006. Edison Electric Institute, Washington, D.C. http://www.aplic.org
16. APLIC (Avian Power Line Interaction Committee), 2012. Mitigating bird collisions with power lines: the state of the art in 2012. Edison Electric Institute, Washington D.C. http://www.aplic.org
17. Birdlife International n.d. Birds and Power Lines within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Power Lines Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents
18. Haas, D., Nipkow, M., Fiedler, G., Schneider, R., Haas, W. & Schürenberg, B., 2005. Protecting birds from powerlines. Nature and Environment, No. 140. Council of Europe Publishing, Strassbourg.
19. Haas, D. & Schürenberg, B. (Eds), 2008. Bird electrocution; general principles and standards of bird protection at power lines (in German). Proceedings of the Conference 'Stromtod von Vögeln, Grundlagen und Standards zum Vogelschutz an Freileitungen' in Muhr am See, April 2006. Ökologie der Vögel, Band 26, Hamburg. http://www.birdsandpowerlines.org
20. Prinsen, H.A.M., J.J. Smallie, G.C. Boere & N. Píres (Compilers), 2011. Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region. CMS Technical Series No. XX, AEWA Technical Series No. XX, Bonn, Germany. http://www.cms.int/species/otis_tarda/meetings/MoS3/documents/GB_Mos3_Doc_07_4_3_Rv1_Guidelines_Infrastructure.pdf
21. Prinsen, H.A.M., Smallie, J.J., Boere, G.C. & Píres, N. (Compilers), 2012. Guidelines on How to Avoid or Mitigate Impact of Electricity Power Grids on Migratory Birds in the African-Eurasian Region. AEWA Conservation Guidelines No. 14, CMS Technical Series No. 29, AEWA Technical Series No. 50. Bonn, Germany. http://www.unep-aewa.org/en/publication/guidelines-how-avoid-or-mitigate-impact-electricity-power-grids-migratory-birds-african
22. Luell, B., Bekker, G.J., Cuperus, R., Dufek, J., Fry, G., Hicks, C., Hlaváˇc, V., Keller, V., B., Rosell, C., Sangwine, T., Tørsløv, N., Wandall, B. le Maire, (Eds.) 2003. Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions.
23. Raab, R., Julius, E., Spakovszky, P. & Nagy, S. (2009): Guidelines for best practice on mitigating impacts of infrastructure development and afforestation on the Great Bustard. Prepared for the CMS Memorandum of Understanding on the conservation and management of the Middle-European population of the Great Bustard. BirdLife International. Brussels. http://www.cms.int/species/otis_tarda/meetings/MoS3/documents/GB_Mos3_Doc_07_4_3_Rev1_Guidelines_Infrastructure.pdf
24. Tucker, G. & Treweek, J. 2008. Guidelines on how to avoid, minimise or mitigate the impact of infrastructure developments and related disturbance affecting waterbirds. AEWA Conservation. Guidelines No. 11, AEWA Technical Series No. 26, Bonn, Germany. http://www.unep-aewa.org/sites/default/files/publication/cg_11_0.pdf
25. Hötker, H., Thomsen, K.-M. & H. Jeromin, 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats - facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut imNABU, Bergenhusen.
26. Fargione, J. E., T. R. Cooper, D. J. Flaspohler, J. Hill, C. Lehman, T. McCoy, S. McLeod, E. J. Nelson, K. S. Oberhauser, and D. Tilman. 2009. Bioenergy and wildlife: threats and opportunities for grassland conservation. BioScience 59(9):767-77.
27. Fargione, J. E., R. J. Plevin, and J. D. Hill. 2010. The ecological impact of biofuels. Annual Review of Ecology, Evolution, and Systematics. 41:351-77.
28. GBEP 2011. The Global Bioenergy Partnership Sustainability Indicators for Bioenergy First edition http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

29. Köppen, S., S. Markwardt, and H. Fehrenbach. 2013. Biofuels Screening Toolkit: Guidelines for Decision Makers.
30. ILUC 2012. Indirect Land Use Change (ILUC) http://europa.eu/rapid/press-release_MEMO-12-787_en.htm
31. National Wildlife Federation. 2013. Perennial Herbaceous Biomass Production and Harvest in the Prairie Pothole Region of the Northern Great Plains: Best Management Guidelines for Achieve Sustainability of Wildlife Resources.
32. Bureau of Land Management and United States Forest Service. 2008. Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States. http://teeic.indianaffairs.gov/er/geothermal/mitigation/eco/index.html
33. Energy Sector Management Assistance Program, 2012. Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey. Ankara, Turkey.
34. Gough, P., P. Philipsen, P.P. Schollema & H. Wanningen, 2012. From sea to source; International guidance for the restoration of fish migration highways.
35. International Centre for Environmental Management, 2007. Pilot Strategic Environmental Assessment in the Hydropower Sub-sector, Vietnam. Final Report: Biodiversity Impacts of the hydropower components of the 6th Power Development Plan. Prepare for The World Bank, MONRE, MOI & EVN, Hanoi, Vietnam.
36. International Centre for Environmental Management, 2010. MRC Strategic Environmental Assessment (SEA) of hydropower on the Mekong mainstream, Hanoi, Vietnam.
37. International Energy Agency, 2006a. Implementing agreement for hydropower technologies and programmes - Annex III, Hydropower and environment: present context and guidelines for future actions, Volume I: Summary and recommendations.
38. International Energy Agency, 2006b. Implementing agreement for hydropower technologies and programmes - Annex VIII, Hydropower good practice: environmental mitigation measures and benefits. New Energy Foundation, Japan.
39. International Energy Agency, 2012. Technology Roadmap – Hydropower. International Energy Agency, Paris, France.
40. International Hydropower Association, 2010. Hydropower Sustainability Assessment Protocol.
41. Lewis, F.J.A., A.J. Harwood, C. Zyla, K.D. Ganshorn, and T. Hatfield. 2013. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88p.
42. Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, A. Killingtveit, Z. Liu, 2011: Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlomer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
43. Office of Investment, 2012. Overseas Private Investment Corporation – Environmental Guidance – Renewable Energy – Hydropower.
44. World Commission on Dams (2000) Dams and development: a new framework for decision making. Earthscan, London and Sterling VA. http://www.internationalrivers.org/resources/dams-and-development-a-new-framework-for-decision-making-3939 and http://www.internationalrivers.org/files/attached-files/world_commission_on__dams_final__report.pdf
45. ACCOBAMS-MOP5/2013/Doc23. Implementation of underwater noise mitigation measures by industries: operational and economic constraints. (under preparation)
46. ACCOBAMS-MOP5/2013/Doc24. Methodological guide: Guidance on Underwater Noise Mitigation Measures (under preparation). http://www.accobams.org/index.php?option=com_content&view=article&id=1164%3Amop5-working-documents-and-resolutions&catid=34&Itemid=65
47. [USDOE] United States Department of Energy. 2009. Ocean Energy Technology Overview.
48. [USDOI] United States Department of the Interior. 2007. Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf. Volume II, Chapter 5.
49. UNESCO Intergovernental Oceangraphic Commission. 2014. http://ioc-unesco.org/index.php?option=com_content&view=article&id=362&Itemid=100036
50. POSTNOTE number 435, 2013. Environmental impact of tidal energy barrages. House of Parliament, Parliamentary office of science & technology.
51. Patton, T., L. Almer, H. Hartmann, and K.P. Smith, 2013, *An Overview of Potential Environmental, Cultural, and Socioeconomic Impacts and Mitigation Measures for Utility-Scale*

Solar Development, ANL/EVS/R-13/5, prepared by Environmental Science Division, Argonne National Laboratory, Argonne, IL, June. Argonne National Laboratory, Chicago, USA.

52. BRE 2014. Biodiversity guidance for solar developments. Eds G E Parker and L Greene. BRE National Solar Centre.
53. Arnett, E.B., G.D. Johnson, W.P. Erickson & C.D. Hein, 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. A report submitted to the National renewable Energy laboratory. Bat Conservation International. Austin, Texas, USA.
54. Arnett, E.b., C.D. Hein, M.R. Schirmacher, M. Baker, M.M.P. Huso & J.M. Szewczak, 2011. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.
55. Band, W., 2012. Using a collision risk model to assess bird collision risk for offshore wind farms. Guidance document. SOSS Crown Estate.
56. BMU Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Concept for the Protection of Harbour Porpoises from Sound Exposures during the Construction of Offshore Wind Farms in the German North Sea (Sound Protection Concept). Report in English.
57. Bowyer, C., D. Baldock, G. Tucker, C. Valsecchi, M. Lewis, P. Hjerp & S. Gantioler, 2009. positive planning for onshore wind. Expanding onshore wind energy capacity while conserving nature. A report by the Institute for European Environmental Policy commissioned by the Royal Society for the Protection of Birds.
58. BSH. 2007a. Standard - Design of offshore wind turbines. Federal Maritime and Hydrographic Agency (BSH).
59. BSH. 2007b. Standard - Investigations of the Impacts of Offshore Wind Turbines on the Marine Environment. Federal Maritime and Hydrographic Agency (BSH).
60. BSH. 2008. Standard – Ground investigations for offshore wind farms. Federal Maritime and Hydrographic Agency (BSH).
61. Cefas, 2010. Strategic review of offshore wind farm monitoring data associated with FEPA Licence Conditions. Project Code ME1117.
62. Cefas, 2004. Guidance note for environmental impact assessment in respect of FEPA and CPA requirements. Prepared on behalf of the Marine Consents and Environmental Unit (MCEU). Version 2, June 2004.
63. Collier, M.P. & M.J.M. Poot, in prep. Review and guidance on use of "shutdown-on-demand" for wind turbines to conserve migrating soaring birds in the Rift Valley/Red Sea Flyway. Report nr. 13-282. Bureau Waardenburg, Culemborg. Report prepared for BirdLife International, under the UNDP-Jordan/GEF Migratory Soaring Birds (MSB) project.
64. DEFRA, 2005. Nature conservation Guidance on Offshore Windfarm Development: a Guidance Note for Developers Undertaking Offshore Wind farm Developments. Prepared by Department of Environment, Food and Rural Affairs.
65. Dillingham P.W. & D. Fletcher 2008. Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relationship. Biol. Cons. 141:1738-1792.
66. Dolman, S.J. and Simmonds, M.P. 2010. Towards best environmental practice for cetacean conservation in developing Scotland's marine renewable energy. Marine Policy, 34, 1021–1027.
67. Drewitt, A.L. & R.H.W. Langston, 2006. Assessing the impacts of wind farms on birds. Ibis 148: 29-42.
68. EUROBATS, 2013. Progress Report of the IWG in "Wind Turbines and Bat Populations". Doc.EUROBATS.AC18.6. UNEP/EUROBATS Secretariat, Bonn.
69. EUROBATS, 2014. Report of the Intersessional Working Group on Wind Turbines and Bat Populations http://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/Doc_StC9_AC19_12_ReportIWG_WindTurbines%20incl_Annexes.pdf
70. European Union 2011, Guidance document, wind energy developments and Natura 2000. http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind_farms.pdf
71. Fox, A.D., M. Desholm, J. Kahlert, T. K. Christensen & I.K. Petersen, 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148: 129-144.

72. Hundt, L., K. Barlow, R. Crompton, R. Graves, S. Markham, J. Matthews, M. Oxford, P. Shepherd & S. Sowler, 2011. Bat surveys – good practice guidelines 2nd edition. Surveying for onshore wind farms. Bat Conservation Trust, London.
73. ICES. 2010. Report of the Working Group on Marine Mammal Ecology (WGMME), 12–15 April 2010, Horta, The Azores. ICES CM 2010/ACOM:24. 212 pp.
74. Jenkins, A.R., C.S. van Rooyen, J.J. Smallie, M.D. Anderson & H.A. Smit, 2011. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa. Produced by the Wildlife & Energy Programme of the Endangered Wildlife Trust & BirdLife South Africa.
75. de Jong, C. A. F., Ainslie, M. A., and Blacquiere, G. 2010. Measuring underwater sound: towards measurement standards and noise descriptors. TNO report TNO-DV 2009 C613. TNO.
76. Koschinski S. & Lüdemann K, 2013. Development of noise mitigation measures in offshore windfarm construction. Commissioned by the Federal Agency for Nature Conservation.
77. Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland & J.M. Szewczak, 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. The Journal of Wildlife Management 71: 2449-2486.
78. Lagrange H., E. Roussel, A.-L. Ughetto, F. Melki & C. Kerbirou (2012) Chirotech – Bilan de 3 années de régulation de parcs éoliens pour limiter la mortalité des chiroptéres. Rencontres nationales « chauves-souris » de la SFEPM (France). (cited in EUROBATS 2013).
79. Lebreton J.D. 2005. Dynamical and statistical models for exploited populations. Aust. N. Z. J. Stat 47(1): 49-63.
80. Ledec, G.C., K.W. Rapp & R.G. Aiello, 2011. Greening the wind. Environmental and social considerations for wind power development in Latin America and Beyond. Full Report. Energy Unit, Sustainable Development Department Latin America and Caribbean Region, The World Bank.
81. Long, C.V., J.A. Flint & P.A. Pepper, 2010. Insect attraction to wind turbines: Does colour play a role? European Journal of Wildlife Research 72: 323-331.
82. Murphy, S., 2010. Assessment of the marine renewables industry in relation to marine mammals: synthesis of work undertaken by the ICES Working Group on Marine Mammal Ecology (WGMME). http://iwc.int/private/downloads/4r0qft5f9vaccwg4ggk0wggws/Synthesis%20of%20work%20undertaken%20by%20the%20ICES%20WGMME%20on%20the%20marine%20renewables%20industry.pdf
83. Nicholls, B. & P.A. Racey, 2009. The aversive effect of electromagnetic radiation on foraging bats – a possible means of discouraging bats from approaching wind turbines. PLoS ONE 4: e6246.
84. Niel C. & J.D. Lebreton 2005. Using demographic invariants to detect overharvested bird populations form incomplete data. Conservation Biology 19(3): 826 – 835.
85. Poot, M.J.M., van Horssen, P.W., Collier, M.P., Lensink, R. & Dirksen, S. 2012. Cumulative Effects of Wind Farms in the Dutch North Sea on Bird Populations. Bureau Waardenburg Research Report 11-026, Culemborg, the Netherlands.
86. Prins, T.C., Twisk, F., Van den Heuvel-Greve, M.J., Troost, T.A. and Van Beek, J.K.L. 2008. Development of a framework for Appropriate Assessments of Dutch offshore wind farms. IMARES report Z4513.
87. Rodrigues, L., L. Bach, M.-J. Dubourg-Savage, J. Goodwin & C. Harbusch, 2008. Guidelines for consideration of bats in wind farm projects. EUROBATS Publication Series No. 3 (English version). UNEP/EUROBATS Secretariat, Bonn, Germany.
88. Smales, I., S. Muir, C. Meredith & R. Baird, 2013. A description of the Biosis model to assess risk of bird collisions with wind turbines. Wildlife Society Bulletin, 37(1), 59-65.
89. Smallwood, K.S., 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71(8): 2781-2791.
90. SMRU Ltd., 2007. Assessment of the potential for acoustic deterrents to mitigate the impact on marine mammals of underwater noise arising from the construction of offshore windfarms. Commissioned by COWRIE Ltd (project reference DETER-01-07).
91. Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J., Gentry, R., Green, C.R., Kastak, C.R, Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., and Tyack, P.L. 2 007. Marine Mammal Noise Exposure Criteria. Aquatic Mammals 33: 411–521.
92. Troost, T., 2008. Estimating the frequency of bird collisions with wind turbines at sea. Guideline for using the spreadsheet “Bird collisions Deltares v1-0.xls”. Deltares, Delft.

93. Tucker, V.A., 1996. A mathematical model of bird collisions with wind turbine rotors. Journal of Solar Energy Engineering 118, 253-262.
94. UNDP-CEDRO, 2011. Environmental Impact Assessment for wind farm developments 2012, a guideline report. Prepared by Biotope for the UNDP-CEDRO Project.
95. USDOE United States Department of Energy, 2011. A national offshore wind strategy: creating an offshore wind energy industry in the United States.
96. U.S. Fish and Wildlife Service, 2012. Land-based wind energy guidelines. U.S. Fish & Wildlife service.
97. Wilhelmsson, D., T. Malm, R. Thompson, J. Tchou, G. Sarantakos, N. McGormick, S. Luitjens, M. Gullström, J.K. Patterson Edwards, O. Amir & A. Dubi, 2010. Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of offshore renewable energy. Gland, Switzerland: IUCN.
98. Williams, D.R., Pople, R.G., Showler, D.A., Dicks, L.V., Child, M.F., zu Ermgassen, E.K.H.J. and Sutherland, W.J. (2012) Bird Conservation: Global evidence for the effects of interventions. Exeter, Pelagic Publishing.
99. van der Winden, J., F. van Vliet, C. Rein & B. Lane, 2014. Renewable Energy Technology Deployment and Migratory Species: an Overview. Report nr. 14-019. Bureau Waardenburg, Boere Conservation Consultancy, Brett Lane & Associates and ESS Group. Commissioned by International Renewable Energy Agency, Convention on Migratory Species, African-Eurasian Waterbird Agreement and Birdlife International, UNDP/GEF/Birdlife MSB project.

Table of contents

Steps towards sustainable deployment

Reducing fossil fuel use by moving to renewable energy is imperative in order to mitigate the worst impacts of climate change to human society as well as to migratory species and biodiversity in general. As with other forms of development, the deployment of renewable energy technology (RET) can however have a range of potentially significant impacts on migratory species if done without carefully planning and consideration of its impacts. These impacts need to be carefully considered both at the strategic and project level. In the strategic phase areas favoured for renewable energy developments are identified. In the project phase the specific location and impacts of specific renewable energy technology developments are considered. Considering cumulative impacts is an essential part of these strategic and project assessments. Careful siting of renewable energy developments is the key to minimizing effects migratory species populations.

The fact that each country or State has different environmental regulations and policies and each renewable energy development process has its own characteristics, makes it difficult to give a straightforward and detailed step-wise approach that can be readily applied to any situation or renewable energy source to avoid or minimize impacts. Given these constraints, this chapter aims to provide a guiding checklist with general steps that need to be taken to avoid or mitigate impacts of renewable energy projects on migratory species, both at a strategic and project level. Taking these steps should ultimately lead to a sustainable deployment of renewable energy in relation to populations of migratory species. The step-wise approach should be seen as a flexible and iterative process: if necessary, steps should be returned to and revised in response to new information and decisions.

Besides the general steps to make as laid down in this chapter, chapter 3 to 8 provide more specific guidance and recommendations per renewable energy source on avoiding and mitigating impacts of renewable energy projects on migratory species.

RET DEVELOPMENT ON STRATEGIC LEVEL

Favoured areas for renewable energy developments need to identified on a broad geographical level (macro-siting) and taken into account in strategic planning on a *national or sub-national* level by carrying out a Strategic Environmental Assessment (SEA)

Step 1 International planning

The first step required is strategic planning of renewable energy technology developments on *international* scale thereby taking into account migratory species populations in the process of site selection for renewable energy developments. For this, international co-operation between developers, policymakers and other stakeholders is needed.

The nature of transboundary movements of migratory animals within their migration range requires that strategic planning procedures have an *international* dimension. Impacts on migratory species in one country or state can have impacts throughout a species' migration range. Moreover, while an individual renewable energy development in one country may be acceptable in terms of its impact on migratory species, the cumulative impact of several developments along the migratory pathway may have significant effects. At national or sub-national levels these issues are difficult to assess. If the planning process is left to the individual countries alone, cumulative impacts might not be recognized.

Sensitivity mapping is a useful tool to assist this strategic planning process of renewable energy developments. Sensitivity maps help visualize the relative sensitivity of areas throughout the migration pathway, to inform the site selection process for future renewable energy developments. Sensitive areas include key migration routes, areas with exceptional concentrations of migratory species, important breeding, feeding or resting grounds and narrow migration corridors. By using sensitivity mapping tools at an early strategic planning stage, high-risk areas with respect to migratory species can be identified (early warning) and the risks for these species can be avoided or substantially reduced by proper macro-siting. This process is vital to maintain the integrity of the migration pathways and the sustainability of renewable energy projects.

The Global Register of Migratory Species (GROMS) database (http://www.groms.de) and the Birdlife Soaring Bird Sensitivity Maps (http://maps.birdlife.org/MSBtool/) together with data repositories on animal tracking and tagging data, such as movebank (http://www.movebank.org) can be useful tools. The IRENA Global Atlas is also a useful tool in this respect at it enables users to visualize information on renewable energy resources, and to overlay additional information to identify areas of interest for further prospection. Also, the worldwide network of Important Bird and Biodiversity Areas (IBA), Ramsar sites or the European Natura 2000-network can be a good start to identify important sites for migratory species. For data deficient areas additional information will be needed to ensure sound decisions.

The review document on RET and migratory species (Van der Winden *et al*. 2015) highlights a number of examples of *potential impact hotspots*. Potential impact hotspots are regarded as sites with concentrations of migratory species, where RET developments might theoretically have serious impact on these species. Identification of potential impact hotspots, both spatial bottlenecks and core spatial resources, along frequently used movement paths is a critical step towards conservation of migratory routes.

This assessment can lead to the recognition that there is a range of areas, where renewable energy developments may have a significant impact on migratory species. When renewable energy projects are planned in these areas, a more detailed impact assessment is necessary.

Step 2 National and sub-national planning (SEA)

This step comprises strategic planning on a *national or sub-national* level by carrying out a SEA. This requires that all countries have introduced legal or other provisions to formalize SEA as a planning requirement at national or sub-national levels. The output from step 1 forms the input for step 2. Steps 1 and 2 mainly differ in terms of geographic scale, the level of detail of the information required for the assessment and the actors involved.

RET DEVELOPMENT ON PROJECT LEVEL

Environmental Impact Assessments (EIAs) for RET need to consider potential impacts on migratory species. The provision for EIA may be made through legislation, administrative order or policy directive. Clear and specific legal provision is internationally accepted as the most appropriate basis for EIA. The EIA process should meet internationally accepted requirements and standards of practice.

The components, stages and activities of an EIA process depend upon the requirements of the country, state or donor. However, most EIA processes have a common structure (see flow chart below) and the application of the main stages is a basic standard of good practice. Each stage should be applied iteratively as part of a 'whole process' approach to provide EIA quality assurance.

Mitigation is the heart of the EIA process. Mitigation should be in accordance with the mitigation hierarchy (avoidance, then minimisation, followed by compensation of impacts) (step 1 – 3 down below). Monitoring (step 4) is essential to evaluate these measures.

Step 1 Avoid impacts (siting)

In this step, the importance of the RET development area for migratory species is assessed, including frequently used movement paths, areas with exceptional concentrations of migratory species, important breeding, feeding or resting grounds and narrow migration corridors over the course of the annual cycle. If the RET development area is not important for migratory species, sustainable RET development is possible with respect to migratory species. For RET developments within the habitat of migratory species the assessment of impacts of RET development and deployment on migratory species is required in an Environmental Impact Assessment (EIA). The responsible authorities (national or regional) should ensure that the impacts on migratory species are included in an EIA and that they are appropriately assessed. Such a process should be as interactive as possible and stakeholder consultation is an absolute requirement.

Priority should be given to the avoidance of impacts on migratory species by siting, planning, or design. Many impacts can be avoided when considered during the siting and design phase. Especially, appropriate **siting** is critically important to avoid impacts. This goes for all forms of RET.

Step 2 Mitigation of site-specific impacts

This step addresses the question of whether measures can be taken to reduce the duration, intensity and / or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, to an acceptable level. The mitigation must be designed to maintain the environmental conditions that exist at the site, that are paramount to the existence of the habitats and species that the site supports.

Mitigation might include habitat restoration after construction or after a site is decommissioned. Habitat restoration measures are taken to rehabilitate degraded ecosystems or restore cleared ecosystems following exposure to impacts that cannot be completely avoided and / or minimised

Mitigation measures can be very RET specific such as “shut-on-demand” mitigation in relation to migratory bat species and wind turbines. Mitigation measures should be carried out during the entire life of the project, from the construction phase, during operation to after decommissioning.

Step 3 Compensation of impacts
In case of residual significant adverse impacts on migratory species after steps 1 and 2, it should be assessed if these impacts can be compensated. In general it is recommended to compensate in time (years) *before* the original habitat is destroyed, so species are able to expand their populations or colonise these areas before any losses take place. Examples of this approach are included in the EU Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) in relation to the establishment of the Natura 2000 network.

Step 4 Evaluation and adaptive management
This step foresees to develop and support evaluation programmes that use standardized protocols to monitor the effectiveness of mitigation and compensation measures and on-going operations. The monitoring results can then be used to improve mitigation measures and also to identify the presence and movements of migratory species for assessment of the (species-specific) scale of impact. Mitigation and compensation measures should be responsive and require data in order to evaluate and allow feedback to enhance their success further.

It is recommended to adopt an adaptive management approach responding to the post-construction monitoring results and reducing negative impacts and identifying enhancement opportunities for migratory species.

On the next page there is a flow diagram for EIA for RET projects that are screened in for EIA with projects with special focus on migratory species. the assessment of RET development This step chart should be seen as a <u>checklist</u> ready for a flexible and iterative process: if necessary, steps should be returned to and revised in response to new information and decisions.

EIA process for RET project that is screened in for EIA considering migratory species (ms)

This is an iterative process, where feedback loops continually provide for input and refinements as new information enters the process. It follows internationally accepted requirements and standards of practice

Input	EIA STAGES	Output
- Baseline data. For a first impression the following instruments can be used: databases migratory species, e.g. (GROMS) database, Birdlife Soaring Bird Sensitivity Maps, Movebank, species distribution atlases. - Relevant Strategic Environmental Assessments to analyse broad alternatives within the RET sector or for a region Relevant legislation, guidelines and standards	**SCOPING** ↓	<u>**Scoping report:**</u> - Identify if RET can have impacts on MS and gaps in knowledge related to MS - Consideration of alternatives, incl. the most environmentally friendly alternative. - Conclusion: - No impacts on MS: no further assessment for MS required, or - Potential impacts on MS: further assessment required
- Scoping report - Review document on RET and MS - Project scale, design, location - Relationship to other projects (cumulative impacts) - Field research, specific data collection	**IMPACT ASSESSMENT** ↓	<u>**EIA report:**</u> - Detailed assessment of the nature and extent of the likely short term and long term relevant impacts on MS - Analysis of the significance of the relevant impacts on MS - Identify need for mitigation measures
- EIA report - Guidelines RET and MS - Approach of mitigation hierarchy: avoid, reduce, restore or compensate	**MITIGATION MEASURES** ↓	<u>**Environmental management and monitoring plan:**</u> - Set out the framework for continuing management, mitigation and monitoring programs for the relevant impacts on MS - Describe appropriate management measures to avoid, minimise or compensate adverse impacts on MS. Sitting is most important. - The institutional requirements for implementation of management measures. - Monitoring program and implementation schedule with before-After-Control-Impact approach: pre- and post-construction assessments, surveys and monitoring
- Environmental management plan	**IMPLEMENTATION AND MONITORING** ↓	<u>**Evaluation report**</u> Monitoring results Check assumptions of EIA: compare predicted and actual impacts Identify effectiveness of mitigation measures Assess need and actions for adaptive management
- Evaluation report - New knowledge	**ADAPTIVE MANAGEMENT AND MONITORING**	<u>**Evaluation report**</u> Identify effectiveness of mitigation measures Assess need for adaptive management

1 Introduction

Climate change impacts

We live today in a world characterised by climate change, impacting not only on life systems but also on the availability of key natural resources. These impacts affect human society as well as other species in our ecosystem, including migratory species which face serious threats that include loss of natural habitats, breeding grounds and migratory routes. The impacts of climate change also exposes migratory species to new emerging threats that we have yet to fully understand. Climate change impacts also threaten global energy, food and water security. Increasing droughts, land degradation, and lack of access to reliable energy sources lead to anthropogenic encroachments, through search for food and biomass for energy, on the habitats and migration routes of wildlife. Therefore, providing solutions to these human challenges stand to benefit migratory species as well (PM).

Renewable energy

Due to increasing concerns about climate change and energy security, there is worldwide an increasing effort to switch over to renewable energy sources, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change shows that the deployment of renewable energy will need to more than triple by 2050 to fight climate change effectively.

A review of effects on migrating species

The production of energy from renewable sources has the potential to make a significant contribution to climate change mitigation (Rogelj *et al*. 2013, Edenhofer *et al*. 2012). By contributing to climate change mitigation, the production of renewable energy also makes a significant contribution to the conservation of biodiversity worldwide (Secretariat of the Convention on Biological Diversity 2010, Gitay *et al*. 2002). Rapid climate change affects ecosystems and species' ability to adapt, with loss of biodiversity as a result. Changes to biodiversity can have profound consequences on ecosystem services for humans. Minimizing the ecological and social consequences of biodiversity changes will preserve options for future solutions to global environmental problems (Chapin *et al*. 2000). Notwithstanding the positive impacts for climate change mitigation, follow-on effects for biodiversity and lower pollution risks, the deployment of renewable energy technologies (RET) can also have negative impacts on wildlife species, including migratory species.

The effects of the deployment renewable energy technologies on migratory species are extensively reviewed in "Renewable Energy Technology Deployment and Migratory Species: an Overview" (Van der Winden *et al*. 2015). That review has been published with the overall objective to contribute to the environmentally sound development of renewable energy and was commissioned by the Secretariats of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and of the Agreement on the Conservation of

African Eurasian Migratory Waterbirds (AEWA) on behalf of the CMS Family[1] and BirdLife International through the UNDP/GEF/Birdlife Migratory Soaring Birds Project.

The international review provides important background information to this guidelines document. The review also highlights the potential growth in renewable energy technology in the coming years and the potential impacts on migratory species. The impacts of RET deployment on migratory species are very project- and site-specific. The nature, scale and degree of impacts will vary according to site- and project specific factors such as the specifications of the development (design, scale, technology), the habitat affected, the species involved, seasonal and diurnal patterns of use of the project site by species. With so many variables involved, it is difficult to make generalizations about impacts of renewable energy deployment on migratory species. Table 1.1 summarizes the main impacts of renewable energy technologies deployment on migratory species groups.

Table 1. Summary of the main impacts of renewable energy technologies deployment on migratory species groups (mammals, birds, fish, reptiles, insects). Due to differences in scale and distribution worldwide effects differ substantially. - = impact on population level is negligible.

Energy source deployed	Regionally or locally high impact, but with no significant impact on the overall species population	Impacts on population level known	Impacts on population level likely
bioenergy		all species groups	- primates, - migrant birds (raptors forest birds)
geothermal	species of fish, birds and mammals	-	-
hydropower	species of fish, birds and mammals	several fish species, one extinction, water-birds	fish, mammals, birds
ocean energy	species of fish, sea turtles birds, crustaceans and squid	-	-
solar power	species of insects, birds and mammals	- (only small scale)	- (only small scale)
wind energy	species of birds and bats	few bird species	birds and bats

In general, the species groups where impacts are most likely to occur include migratory birds, mammals and fish. The main (potential) impacts of RET deployment on migratory species are habitat loss, habitat degradation, disturbance, barrier effects and direct mortality. The review shows a few examples where population effects of RET deployment have been demonstrated (*e.g*. hydropower and fish and wind energy and raptors).

[1] Convention on the Conservation of Migratory Species of Wild Animals (CMS) and its associated agreements are defined as the CMS Family. The project is relevant for the whole Family, but it is managed by the CMS and AEWA Secretariats on behalf of the Family.

A number of gaps in the knowledge exist, which can impede assessments of potential impacts. Relatively few impacts have been well documented. Most papers and reviews include speculations on impacts. This is partly caused by the lack of proper pre- and post-construction monitoring, which can lead to the exaggeration or underestimation of effects.

Guidelines for mitigation and avoiding impacts: purpose and approach

In recent years several guideline documents have been published worldwide describing approaches and solutions to avoid/mitigate conflicts between renewable energy technology deployment and wildlife. Most of these existing documents are drawn up for the deployment of a specific renewable energy technology and without special emphasis on migratory species. This current guideline report aims to integrate and summarize these key documents in one overview with special focus on migratory species. It presents solutions, technical as well as legislative, which are being applied for avoiding/mitigating impacts, including factors determining or constraining their effectiveness and synthesizes lessons learned from past experiences. Detailed technical guidance on the construction of mitigation measures are outside the scope of these guidelines, for these we refer to existing technical literature. There are numerous examples of such detailed guidelines and explicit reference will be made to these, rather than repeating the content of these documents, even in summary form.

The guidelines detailed in this report have been developed primarily for governmental policy officers and project developers working with renewable energy technologies. This report is expected to be of value also to consultants, site managers, non-government organisations (NGOs) and other practitioners who are involved in the planning, design, implementation or approval of renewable energy plans or projects.

Methodology

This guidelines report draws on existing guidance documents. The internet databases ISI Web of Knowledge, Zoological Record and JSTOR were searched, as well as the internet search engine GoogleTM. The focus was on English documents and there was no thorough survey in other languages. It may be assumed that there will be many examples published in other languages but the important issues will be recognized in recent English reviews or overviews. If some gaps are identified these are not necessarily due to the lack of references, but possibly due to the limitations of the methodology

Literature

Chapin, F.S., III, E.S. Zaveleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, S. Lavorel, H.L. Reynolds, D.U. Hooper, O.E. Sala, S.E. Hobbie, M.C. Mack, and S. Diaz. 2000. Consequences of changing biotic diversity. Nature 405: 234-242.

Edenhofer O, Pichs-Madruga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S. 2012. IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation.

Gitay, H., A. Suarez, and R.T. Watson. 2002. Climate change and biodiversity: IPCC Technical Paper V. Intergovernmental Panel on Climate Change. Geneva. 77 pp.

Rogelj J., D.L. McCollum & K. Riahi 2013. The UN's 'Sustainable Energy for All' initiative is compatible with a warming limit of 2 °C. Nature Climate Change 3, 545–551.

Secretariat of the Convention on Biological Diversity, 2010. Global Biodiversity Outlook 3. Montréal.

Van der Winden, J., F. van Vliet, C. Rein & B. Lane, 2014. Renewable Energy Technology Deployment and Migratory Species: an Overview. Report nr 14-019. Bureau Waardenburg bv, Culemborg.

2 General guidelines

2.1 Introduction

There are some basic principles and approaches that apply to most forms of renewable energy development. For example, the vast majority of commercial scale energy deployment (both renewable and non-renewable) will make use of some form of transmission infrastructure (*e.g.* aboveground power lines, belowground cables) to transport and/or further distribute the power generated to the national and international grids. Although transmission infrastructures will be similar to those for non-renewable energy, the location requirements of some sources of renewable energy may lead to the deployment of infrastructures in areas for which they would not have otherwise been needed for non-renewables alone. This is similar for transport infrastructure, which is needed to allow construction and maintenance traffic.

This report concentrates on guidelines specific to the exploitation phase of renewable energy developments. Many guidelines exist for the construction phases for such developments throughout the world and where these are not specific to renewable energy we refer to those existing guidelines. Furthermore, this report does not aim to define criteria for the selection of renewable energy technologies. This is determined largely by governments, need, technological capabilities, economics and market forces. This report aims to provide guidelines for minimizing the negative impacts of the deployment of renewable energy technology on migratory species.

Below a brief guidance is given on such general aspects, referring mostly to other published guidelines on the topics of legislation, Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) procedures, transport infrastructure, transmission and distribution infrastructures and monitoring of impacts. SEA should normally be undertaken earlier in the decision-making process than the project-specific EIA. In practice, these two procedures often overlap and alternatives and environmental effects are considered throughout the various stages of planning and project implementation.

The impacts arising from a specific project depend on a great range of variables, one of these is size. As for other forms of development, when all other factors are equal, a large development will have more impact than a small one. Many other factors also influence the type and scale of effects on migratory species. Location is very important and a poorly sited development can have more impact than a larger one elsewhere. With particular regard to migratory species, the level of impact will not be restricted to the project area only. Any negative impact at a given project site may influence a species or population throughout its range. As for other forms of developments, the potential impacts from renewable energy technologies on migratory species can be cumulative, resulting from combinations of comparable or different renewable energy deployments, as well as from other developments and environmental pressures.

This chapter concludes with a ‘guide to guidelines’, which lists the recommended sources of information and guidance on these topics. If available, more specific guidelines on these topics for each renewable energy technology deployment will be presented in chapters 3-8.

2.2 Legislation, policy and Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) procedures

2.2.1 Legislation and policy

A wide range of legal and semi-legal obligations exist to stimulate renewable energy developers to reduce impacts of renewable energy technology deployment on migratory species through strategic planning and/or applying appropriate mitigation or compensation measures. These obligations are incorporated in national legislation as well as in international conventions, treaties or Memoranda of Understanding.

In Europe, the Habitats and Birds Directives provide guidelines for the protection of biodiversity. Article 6 of the Habitats Directive sets out a series of guidelines that must be applied to plans and projects that are likely to have a significant effect on a Natura 2000 site.

Most countries now have legislation that requires an Environmental Impact Assessment for the construction and exploitation of renewable energy power plants (*i.e.* wind farms, hydropower dams, solar power stations, *etc*.). For the last several decades, Strategic Environmental Assessment (SEA) regulations have also been introduced in many countries. Many countries now have either national legislative or other provisions for SEA, e.g. statutory instruments, cabinet and ministerial decisions, circulars and advice notes. Especially the EIA process makes sure that international and national habitat and wildlife conservation legislation is taken into account in renewable energy developments. How strict, well applied and enforced that conservation legislation is, can have significant influence over:

- How renewable energy technology deployment is placed in the landscape;
- The mitigation measures that are applied;
- The decisions that no renewable energy technology deployment can be constructed in certain places because of overriding conservation interests;
- The obligation to compensate negative impacts that cannot be mitigated (*e.g.* as addressed in the EU under the Habitats Directive).

A strategic planning procedure (supported by SEA) aims to find the right siting of renewable energy technology deployment so as to avoid, and where avoidance is not possible reduce, the impact on the environment, landscape and biodiversity (in the broadest sense) to the minimum. A SEA at a national or regional scale, which at an early stage aims to ensure that environmental and possibly other sustainability aspects are considered effectively in policy, informs plan and programme making and weighs the overall need to develop renewable energy technology deployments (see below). A site-specific EIA seeks to integrate environmental considerations into the design and operation of a development.

Currently, there are few international conservation instruments that have specific recommendations and actions formulated for Parties on the possible impacts of renewable energy technology deployment and migratory species, wind energy deployment and power line infrastructure being a notable exception. Most international important conservation instruments have more general obligations that ask for well-applied standardised SEA and EIA procedures (see below). Legislation specific for renewable energy deployment will be dealt with in the renewable energy deployment specific chapters.

Relevant international nature and biodiversity Conventions and Agreements (see also Annex I in European Union (2011) and Annex 4 in Wilhelmsson et al. 2010)

- The Convention on the Conservation of European Wildlife and Natural Habitats ('Bern Convention') – Recommendation No. 109 (2004) on minimizing adverse effects of wind power generation on wildlife (Adopted by the Standing Committee on 3 December 2004)
  http://www.coe.int/t/dg4/cultureheritage/nature/bern/default_en.asp
- Bonn Convention on the Conservation of Migratory Species of Wild Animals (CMS) – CMS Resolution 7.5 on Wind Turbines and Migratory Species (2002)
  http://www.cms.int/en/document/wind-turbines-and-migratory-species
- Directive 79/409/EEC on the Conservation of Wild Birds (Birds Directive)
  http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm
- Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (Habitats Directive)
  http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
- Directive 2001/42/EC The assessment of the effects of certain plans and programmes on the environment (SEA Directive)
  http://ec.europa.eu/environment/eia/sea-legalcontext.htm
- Protocol on Strategic Environmental Assessment (Kyiv, 2003) – A strategic environmental assessment shall be carried out for (amongst others) installations for the harnessing of wind power for energy production (Annex II)
  http://www.unece.org/env/eia/sea_protocol.html
- The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) – AEWA MOP Resolution 5.16 on Renewable Energy and Migratory Waterbirds; La Rochelle, France, 18 May 2012. Calls upon contracting parties to undertake specific measures to reduce the potential negative impact of terrestrial as well as marine wind farms on waterbirds
  http://www.unep-aewa.org/en/documents/agreement-text
- Agreement on the Conservation of Populations of European Bats; London, UK, 4 December 1991. (EUROBATS) – Resolution on the potential impact of wind farms on bats adopted in 2003
- http://www.eurobats.org/official_documents/agreement_text

- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) – Resolution on adverse effects of sound, vessels and other forms of disturbance on small cetaceans adopted in 2006
  http://www.ascobans.org
  Resolution No. 2 Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production
  http://www.ascobans.org/sites/default/files/basic_page_documents/MOP6_2009-2_UnderwaterNoise.pdf
- Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) – OSPAR Guidance on Environmental considerations for Offshore Wind Farm Development (2008)
  http://www.ospar.org/content/content.asp?menu=01481200000000_000000_000000
- Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991) – Parties shall establish an environmental impact assessment procedure that permits public participation for (amongst others) major installations for the harnessing of wind power for energy production (Annex I)
  http://www.unece.org/env/eia/eia.html

2.2.2 Strategic Environmental Assessments (SEA) and Environmental Impact Assessments (EIA)

Planning renewable energy deployment in a strategic manner over a wider geographical area is one of the most effective means of minimizing the impacts of renewable energy deployment on migratory species. Strategic Environmental Assessments (SEAs) followed up with site specific Environmental Impact Assessments (EIAs) are the necessary tools to ensure that the impacts of renewable energy deployment on migratory species are minimized and they should be in place and applied.

The European Directive (2001/42/EC) on the Assessment of the Effects of Certain Plans and Programmes on the Environment, known as the SEA Directive, is one of the international instruments that prescribes the application of SEA. The Directive came into effect in 2004 and applies to member states of the European Union. It requires an environmental assessment for certain plans and programmes at national, regional and local level that are likely to have significant effects on the environment. A similar provision is contained in the SEA Protocol to the Espoo Convention (UNECE Convention on EIA in a Transboundary Context; Kiev, 2003). This protocol is an international agreement dealing with transboundary effects in the Espoo Convention. This protocol includes a separate article encouraging the use of SEA in the context of policies and legislation and is adopted by several countries. As migratory species pass through different countries or over oceans, international SEA is required under the SEA protocol to the UNECE Espoo Convention. The nature of migratory species means that they may only use certain areas for limited periods. Even for areas through which species only migrate developments have the potential to have an impact on these species. Any assessment or monitoring needs to take into account the temporal changes in species presence. Monitoring should take into account temporary changes in abundance of species and be carried out in the appropriate seasons and at appropriate times. Temporal variation between years should also be taken into account.

Often SEA is approached as a way to balance every interest including economic and social ones. However, it is intended as a tool for environmental policy integration, *i.e.* to raise the profile of environmental considerations in planning through bringing development and environmental plans and conservation priorities together to ensure that conflicts and cumulative impacts are minimized and development is appropriate. SEAs should consider the cumulative impacts of multiple renewable energy projects in conjunction with other renewable and non-renewable energy developments in a given region. Although relevant for all sectors and scales it is particularly effective with respect to large scale planning of renewable energy generation plants (*i.e.* wind farms, solar arrays, hydropower plants, *etc*.) as areas with least conflict can be identified proactively and sensitive areas can be avoided, well before reaching the individual project stage. The EIA process allows for the assessment of impacts at project level. Although project-based and comparatively later in the planning process, the EIA is an essential mechanism for minimizing impacts on migratory species.

Already at this early stage of policy- and decision-making, information on sensitive areas, migratory species presence and migration routes should be collected from available sources or, if not available, collected in a programme of field research over a period of at least one year. For those sites with few existing data or which are used by species that show high levels of inter-annual variation, a minimum of two years data collection should apply, notably at sea (Gove *et al*. 2013). Having data is essential during planning to avoid conflicts with national and international conservation legislation and to reduce the potential impacts of renewable energy technology deployment on protected species.

The importance of ensuring the availability of data on migratory species and determining the presence or absence of sensitive and/or protected areas before or during SEA and EIA procedures cannot be emphasized enough. Effective precautionary planning of renewable energy deployment, using data on the presence of migratory species and their migration routes, can already substantially avoid and reduce the problem of negative interactions between renewable energy technology deployment and migratory species. Unfortunately, in some countries, particularly many developing countries, data are scarce and resources to carry out detailed field research to collect relevant data are lacking. Mechanisms to address this problem including the provision of know-how and financial support should ideally be established. Although this is generally funded by developers through EIA procedures at the project-level, more extensive power plant construction programmes could be facilitated by governments through National Development Agencies or international funds such as through the Global Environmental Facility (GEF). This should also work for countries that would like to replace and/or adjust existing facilities which have significant impacts on migratory species.

Environmental Impact Assessments (EIAs) for RET need to consider potential impacts on migratory species. The provision for EIA may be made through legislation, administrative order or policy directive. Clear and specific legal provision is internationally accepted as the most appropriate basis for EIA. The EIA process should meet internationally accepted requirements and standards of practice.

Normally, the project proponent carries out the EIA in accordance with directions given by the competent authority. An environment agency (or a specialised EIA body) oversees the process and reviews the EIA study. Usually, EIA studies are carried out by an interdisciplinary team, which is appointed specifically to the task and has an appropriate range of scientific, and other expertise. Public or stakeholder involvement is a fundamental principle of the EIA process. In practice, there are marked differences in specific requirements for public involvement. The purpose of public involvement is to: 1) inform the stakeholders about the proposal and its likely effects, 2) to take account of the information and views and concerns of the public in the EIA and decision making.

The components, stages and activities of an EIA process depend upon the requirements of the country, state or donor. However, most EIA processes have a common structure (see flow chart below) and the application of the main stages is a basic standard of good practice. Each stage should be applied iteratively as part of a 'whole process' approach to provide EIA quality assurance.

Mitigation is the heart of the EIA process. Mitigation should be in accordance with the mitigation hierarchy (avoidance, then minimisation, followed by compensation of impacts). Monitoring (step 4) is essential to evaluate these measures.

More detailed information on the SEA and EIA processes and their benefits for nature conservation can be obtained from Ramsar Resolution X.17 '*Environmental Impact Assessment and Strategic Environmental Assessment: updated scientific and technical guidance, 2008*', the Bern Convention Technical Information document T-PVS/Inf15e_2013, titled '*Wind farms and birds: an updated analysis of the effects of wind farms on birds, and best practice guidance on integrated planning and impact assessment*' (Gove *et al*. 2013), the AEWA Conservation Guidelines No. 11, titled '*Guidelines on how to avoid minimise or mitigate the impact of infrastructure developments and related disturbance affecting birds*' (Tucker & Treweek, 2008), the MSB guidance on wind, solar and transmission lines, The OECD DAC Guidance on SEA: Applying Strategic Environmental Assessment. Good Practice Guidance for Development Co-operation (OECD 2006) and Convention on Biological Diversity (CBD) Biodiversity in EIA and SEA — background document to CBD decision VIII/28: guidelines on biodiversity-inclusive impact assessment (Slootweg R., A. Kolhoff, R. Verheem, R. Hoft 2006). These are helpful and practical documents providing steps necessary for planning and the application of SEA and EIA. Annex B of AEWA Guideline 11 lists international conventions and other legislation that requires impact assessments with related guidance in information documents.

2.3 Power transmission and distribution infrastructure

Renewable power generation plants, like all centralized electricity generation facilities, need infrastructure to connect them to the electricity grid. Especially where these connections exist as aboveground power lines, impacts on migratory species are likely to occur. Aboveground power lines are one of the major causes of unnatural deaths for birds in large parts of the world, with an estimated many millions of victims of electrocution or collision each year. Also migratory bat species may be affected, especially the larger ones, which may suffer from electrocution when using medium voltage power lines for roosting.

For detailed guidance on appropriate actions, both legislative as well as technical, best practice for constructing power lines, the state-of-the-art mitigation/avoidance measures and evaluation and monitoring practices we refer to AEWA/CMS 'Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region' (Prinsen *et al.* 2011) and references therein. Reference is also made to the 'Guidance on appropriate means of impact assessment of electricity power grids on migratory soaring birds in the Rift Valley / Red Sea Flyway' (Gyimesi & Prinsen in prep.) and BirdLife guidance for this region: http://migratorysoaringbirds.undp.birdlife.org/en/documents. For further detailed technical guidance on the avoidance and mitigation of impacts of electricity power grids we recommend Avian Power Line Interaction Committee (APLIC; 2006, 2012), Haas *et al*. (2005) and Haas *et al*. (2008).

2.4 Transport infrastructure

Effects during the construction of renewable energy power generation plants, including access infrastructure, storage and work areas, generally reflect those for similar construction projects and can include mortality (*e.g.* road kill) as well as direct or indirect disturbance effects, increased access for poachers, habitat loss, habitat or migration route fragmentation and/or -degradation.

For detailed guidance we refer to AEWA Conservation Guidelines no. 11 'Guidelines on how to avoid, minimize or mitigate the impact of infrastructure developments and related disturbance affecting waterbirds' (Tucker & Treweek 2008) and 'Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions' (Luell *et al*. 2003).

2.5 Pre-construction assessment and pre- and post-construction monitoring

The accompanying review document 'Renewable energy technology deployment and migratory species: an overview' shows that for large parts of the world, most notably Asia, Africa and South America, limited research and monitoring data are available on the interaction of renewable energy technology deployment and migratory species. The collection of field data through pre- and post-construction monitoring for any new renewable energy development is key in getting better insights into the magnitude of the problem and the species involved in these regions.

It is important that pre- and post-construction assessments, surveys and monitoring adopt a standard and repeatable approach, consistent with methods used at other renewable energy developments. The value of having a Before-After-Control-Impact (BACI) approach cannot be over emphasized and should be taken as best practice. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas. This will allow comparisons between different renewable energy developments and the generation of more reliable and evidence-based estimates of impacts founded on a range of studies. This will in turn help the more accurate prediction of impacts of future developments. Standardized post-construction monitoring is also needed to assess the effectiveness of mitigation measures that are applied and investigate the predicted impacts. Finally, studies should also assist cumulative impact assessments for particular species as the results of similar studies can be readily combined.

It is, therefore, critical that resources are not only allocated to implement pre- and post-construction monitoring but that the results of these monitoring programmes are reported and published for wider use.

Monitoring strategies for specific renewable energy technology deployments (for instance, the monitoring of bat and bird casualties at wind farms) will be dealt with in the following chapters 3-8.

2.6 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidance; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

Strategic planning, legislation and SEA and EIA procedures

BirdLife International 2014 The MSB Sensitivity Mapping http://migratorysoaringbirds.undp.birdlife.org/en/sensitivity-map

Birdlife International n.d. Birds and Wind Farms within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Wind Energy Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents

Birdlife International n.d. Birds and Solar Energy within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Solar Energy Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents

Burger, J. & M. Gochfeld,, 2012. A Conceptual Framework Evaluating Ecological Footprints and Monitoring Renewable Energy: Wind, Solar, Hydro, and Geothermal. Energy and Power Engineering, Vol. 4 No. 4, 2012, pp. 303-314. doi: 10.4236/epe.2012.44040.

Convention on Biological Diversity (CBD) 2014.Identification, monitoring, indicators and assessments. COP 6 Decision VI/7. http://www.cbd.int/decision/cop/?id=7181

Gove, B., R.H.W. Langston, A. McCluskie, J.D. Pullan & I. Scrase. Wind farms and birds: an updated analysis of the effects of wind farms on birds, and best practice guidance on integrated planning and impact assessment. RSPB/BirdLife in the UK. Technical document T-PVS/Inf(2013)15 to Bern Convention Bureau Meeting, Strasbourg, 17 September 2013.

Gyimesi A. & Prinsen H.A.M., in prep. Guidance on appropriate means of impact assessment of electricity power grids on migratory soaring birds in the Rift Valley / Red Sea Flyway. Bureau Waardenburg, Culemborg.

IUCN 2014. IUCN Red List of Threatened Species. http://www.iucnredlist.org

Rajvanshi, A. 2008. Mitigation and compensation in environmental assessment. Chapter 17 in T.B Fischer, P. Gazzola, U. Jha-Thakur, I. Belcakova, and R, Aschemann, eds. Environmental Assessment Lecturers' Handbook, EC Penta Erasmus Mundus Project, February 2008. http://www.twoeam-eu.net/handbook/05.pdf.

Ramsar Convention on Wetlands 2008. Resolution X.17 Environmental Impact Assessment and Strategic Environmental Assessment: Updated Scientific and Technical Guidance. www.ramsar.org/pdf/res/key_res_x_17_e.pdf

Slootweg R., A. Kolhoff, R. Verheem, R. Hoft 2006. Biodiversity in EIA and SEA — background document to CBD decision VIII/28: guidelines on biodiversity-inclusive impact assessment. The Netherlands: Commission for Environmental Assessment.

The OECD DAC Network on Environment and Development Co-operation (ENVIRONET) SEA Guidance and Advisory Notes (all available at the SEA Task Team website. http://www.seataskteam.net/guidance.php

The OECD DAC Guidance on SEA: Applying Strategic Environmental Assessment. Good Practice Guidance for Development Co-operation, OECD, Paris. http://www.oecd.org/dac/environment-development /37353858.pdf

United Nations 2014. The Integrated Biodiversity Assessment Tool (IBAT). https://www.ibatforbusiness.org/login and http://business.un.org/en/documents/ 8112 and http://www.unep-wcmc.org/system/dataset _file_fields/files/000/000 /090/original/IBAT-overview.pdf?139844 0561

Power lines

APLIC (Avian Power Line Interaction Committee), 2006. Suggested practices for avian protection on power lines: The state of the art in 2006. Edison Electric Institute, Washington, D.C. http://www.aplic.org

APLIC (Avian Power Line Interaction Committee), 2012. Mitigating bird collisions with power lines: the state of the art in 2012. Edison Electric Institute, Washington D.C. http://www.aplic.org

Birdlife International n.d. Birds and Power Lines within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Power Lines Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents

Haas, D., Nipkow, M., Fiedler, G., Schneider, R., Haas, W. & Schürenberg, B., 2005. Protecting birds from powerlines. Nature and Environment, No. 140. Council of Europe Publishing, Strassbourg.

Haas, D. & Schürenberg, B. (Eds), 2008. Bird electrocution; general principles and standards of bird protection at power lines (in German). Proceedings of the Conference 'Stromtod von Vögeln, Grundlagen und Standards zum Vogelschutz an Freileitungen' in Muhr am See, April 2006. Ökologie der Vögel, Band 26, Hamburg. http://www.birdsandpowerlines.org

Prinsen, H.A.M., J.J. Smallie, G.C. Boere & N. Píres (Compilers), 2011. Guidelines on how to avoid or mitigate impact of electricity power grids on migratory birds in the African-Eurasian region. CMS Technical Series No. XX, AEWA Technical Series No. XX, Bonn, Germany. http://www.cms.int/species/otis_tarda/meetings/MoS3/documents/GB_Mos3_Doc_07_4_3_Rev1_Guidelines_Infrastructure.pdf 6333

Prinsen, H.A.M., Smallie, J.J., Boere, G.C. & Píres, N. (Compilers), 2012. Guidelines on How to Avoid or Mitigate Impact of Electricity Power Grids on Migratory Birds in the African-Eurasian Region. AEWA Conservation Guidelines No. 14, CMS Technical Series No. 29, AEWA Technical Series No. 50. Bonn, Germany. http://www.unep-aewa.org/en/publication/guidelines-how-avoid-or-mitigate-impact-electricity-power-grids-migratory-birds-african

Construction and infrastructure development

Luell, B., Bekker, G.J., Cuperus, R., Dufek, J., Fry, G., Hicks, C., Hlaváˇc, V., Keller, V., B., Rosell, C., Sangwine, T., Tørsløv, N., Wandall, B. le Maire, (Eds.) 2003. Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions.

Raab, R., Julius, E., Spakovszky, P. & Nagy, S. (2009): Guidelines for best practice on mitigating impacts of infrastructure development and afforestation on the Great Bustard. Prepared for the CMS Memorandum of Understanding on the conservation and management of the Middle-European population of the Great Bustard. BirdLife International. Brussels. http://www.cms.int/species/otis_tarda/meetings/MoS3/documents/GB_Mos3_Doc_07_4_3_Rev1_Guidelines_Infrastructure.pdf

Tucker, G. & Treweek, J. 2008. Guidelines on how to avoid, minimise or mitigate the impact of infrastructure developments and related disturbance affecting waterbirds. AEWA Conservation. Guidelines No. 11, AEWA Technical Series No. 26, Bonn, Germany. http://www.unep-aewa.org/publications/conservation_guidelines/ pdf/cg_11.pdf

Renewable energy in general

Hötker, H., Thomsen, K.-M. & H. Jeromin, 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats - facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut imNABU, Bergenhusen.

3 Bioenergy

3.1 Main impacts

The potential impacts of bioenergy on migratory species include direct mortality, disturbance, habitat loss, habitat fragmentation and habitat degradation. Habitat loss and degradation are the main impacts of bioenergy technology on migratory species. Birds and terrestrial mammals are the primary species groups that can be affected, but also fish can be impacted. Bioenergy can be produced using a variety of feedstocks and methods. Hence, the (potential and significance of) impacts of bioenergy on migratory species are variable. Moreover, the impacts are both site- and species-specific. In this chapter, we focus on larger scale production of biofuels for bioenergy. In general, bioenergy from dedicated feedstocks is characterized by relatively large land use requirements and potentially relatively large water use requirements. Land use and change and water use are the main issues of concern with respect to impacts of bioenergy on migratory species.

Construction and decommissioning

- Habitat loss and fragmentation for birds and terrestrial mammals due to construction of biomass energy facilities, access roads and power lines.
- Habitat degradation for birds, terrestrial mammals and fish due to water use and emissions of chemicals and wastes to surface water.
- Disturbance of birds and terrestrial mammals by noise, light etc. due to construction activities.
- Mortality of birds and terrestrial mammals due to construction activities, chemical spills and vehicle strikes.

Operational

- Habitat loss and fragmentation for terrestrial mammals and birds due to direct and indirect land use change and clear-cutting of forests for and during fuel production.
- Habitat degradation for terrestrial mammals and birds due to intensified agriculture and forestry practices and increased extraction of wood. The use of crop residues as biofuel decreases the availability of this resource for migratory wildlife. Reduction in available water particularly in dry areas may result in the loss of wetlands and water resources at vital stopover sites for migrants. Lower food and water availability may lead to increased mortality and lower population sizes.

For a detailed description of the impacts of bioenergy developments on migratory species we refer to the review of Van der Winden *et al*. (2014).

3.2 Legislation, policy and SEA and EIA procedures

The processes involved in bioenergy production are diverse. These range from the production of biomass for biofuels, the production of biofuels, which in itself can refer to several procedures and the use of biofuels in bioenergy plants. Due to this complexity, any existing legislations and policies are likely to cover only part of these processes. For several of the procedures, such as biomass production, existing legislation is likely to be less relevant than for example, the construction of a bioenergy plant. The Global Bioenergy Partnership Sustainability Indicators for Bioenergy and Indirect Land Use Change (ILUC) address some of these areas.

Legislation and Policy

There has been a great deal of interest in incorporating bioenergy into national energy portfolios in recent years. This is accomplished in part through the use of biofuels blended with traditional fossil fuel based liquid transportation fuels, combustion of solid biomass for electricity and/or heating (for a full overview see the Review Report). In Europe, electricity production and heating are the largest sectors using modern bioenergy technology. However, relatively few policy initiatives or legislative actions have been implemented related to bioenergy, biomass or biofuel production and mitigating impacts to migratory wildlife. Example are the EU Renewable Energy Directive sustainability criteria for liquid biofuels used in the transport sector. Also, few policies exist for tropical regions, which have a high potential and interest in biomass production for bioenergy as well as significant and sensitive migratory wildlife and habitat resources. Examples of legislation and policy initiatives for two the world's largest producers of biofuels, the United States and Brazil, are given in box 3.1.

Box 3.1 Examples of biofuel-related legislation in the Americas

United States

- American Recovery and Reinvestment Act of 2009 – supports funding for a variety of alternative fuel and advanced vehicle technology grant programmes, research and development initiatives, and fleet improvement programmes.
- Emergency Economic Stabilization Act/Energy Improvement and Extension Act of 2008 – amends and extends existing biodiesel blending and production tax credits, extends the existing alternative fuel excise tax, and extends the alternative fuelling infrastructure tax credit.
- Energy Independence and Security Act of 2007 – includes provisions to increase the supply of renewable alternative fuel sources by setting a mandatory Renewable Fuel Standard, which includes the use of cellulosic biofuels and biomass-based diesel fuels.
- Energy Policy Act of 2005 – established renewable electricity production tax credits for electricity generated from biomass crops that are planted exclusively for the purpose of being used to produce electricity.
- Farm Security and Rural Investment Act of 2002 – included significant incentives for biomass production and use and funded numerous projects from biomass production issues to improvements in refinery production processes.

Brazilian Biofuel Initiative

In a 105-page report (undated but 2009 or later) titled "The Future for Bioenergy and Biomass Brazil" by the Brazilian Association of Industry Biomass and Renewable Energy (ABIB), the words "wildlife" and "habitat" appeared only once. The Brazilian Biodiesel Production and Use Program (described in more detail below) also did not address impacts of biomass energy expansion on migratory wildlife or habitats. These examples demonstrate a lack of focus on the impacts to migratory wildlife and their habitats from biomass fuel crop cultivation and harvesting, including in ecologically diverse and sensitive tropical regions.

Strategic Environmental Assessments (SEAs)

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. SEAs, strategic planning and landscape planning for biomass production for bioenergy can be an important tool for planning, managing, and mitigating the impacts of this renewable energy technology on migratory species. However, in Europe changes to agricultural land use or forests are not subject to spatial planning, so SEA does not typically take place. Because habitat loss and degradation can have a significant impact to migratory species, SEAs should be conducted for the purposes of planning and implementing large-scale biomass production for bioenergy programmes in the most environmentally- and socially-conscious manner practicable. An example of an SEA prepared biofuel production programme is given in box 3.2.

Box 3.2. SEA framework to quantify the environmental impact of bioenergy plans

Finnan et al (2011) quantified the environmental impact of an Irish Government bioenergy plan to replace 30% of peat used in three peat-burning power stations, located within the midlands region, with biomass. The environmental impact was assessed in compliance with the EU Strategic Environmental Assessment (SEA) Directive (2001/42/EC). Four plan alternatives for supplying biomass to the power plant were considered in this study: (1) importation of palm kernel shell from south-east Asia, (2) importation of olive cake pellets from Spain and (3) growing either willow or (4) Miscanthus in the vicinity of the power stations. The impact of each alternative on each of the environmental receptors proposed in the SEA Directive was first quantified before the data were normalized on either an Irish, regional or global scale. Positive environmental impacts were very small compared to the negative environmental impacts for each of the plan alternatives considered. Comparison of normalized indicator values confirmed that the adverse environmental consequences of each plan alternative are concentrated at the location where the biomass is produced. The analysis showed that the adverse environmental consequences of biomass importation are substantially greater than those associated with the use of willow and Miscanthus grown on former grassland. The use of olive cake pellets had a greater adverse environmental effect compared to the use of peat whereas replacement of peat with either willow or Miscanthus feedstocks led to a substantial reduction in environmental pressure. The proposed assessment framework combines the scope of SEA with the quantitative benefits of life cycle assessment and can be used to evaluate the environmental consequences of bioenergy plans (abstract from Finnan et al. 2011).

Environmental Impact Assessments (EIAs)

Environmental Impact Assessments are a crucial tool in determining the impacts of biomass fuel cultivation and harvesting practices to migratory wildlife and their habitats. However, in Europe EIAs are unlikely to be required for changes in crop production on agricultural land. Assessments for biomass fuel production should however focus on the species that are primarily impacted by biomass energy developments, primarily grassland and forest bird species and terrestrial mammals. With regard to migratory birds, EIAs should aim to determine the importance of a potential project area for migratory birds, with respect to availability of resources (food, water, cover, breeding, *etc*.) and how the resources may be affected by the habitat changes entailed by the project. The presence of threatened or endangered species in the project area at any time during the annual life cycle of the species should also be considered as part of the EIA. The EIA should also identify potential mitigation measures that could help to lessen the impact to migratory species from the habitat changes that are expected to result from the project.

3.3 Best practice of mitigation

Many of the negative effects can be reduced or avoided through choice of biomass feed stocks for energy use, resource efficient use of biomass, good practice in siting of crop production and plants and sustainable land and forestry management, including planting strategies, the timing and method of harvesting and choice of crops. The principles of good practice listed below provide key points of good practice for biomass energy production, which could be exercised to minimize adverse impacts on migratory species and maximize benefits. For further information, practitioners need to refer to more detailed published guidance.

<u>Siting</u>

- Target biomass production for bioenergy to areas of low conservation value, preferably not suitable for food or feed production to avoid converting areas of high conservation value, including as native habitats, to biofuel production fields (Fargione *et al*. 2010). Avoid conversion of areas of high conservation value and to avoid competition over agricultural land leading to displacement of food and feed production priority areas for conservation.
- Locate bioenergy plants so that they can rely on local biomass resources and be able to assess the impacts of the biomass production, rather than relying on biomass transported over long distances or imported.

<u>Designing, sustainable land and forestry management</u>

- Use biofuels that do not require additional land resources, compete over food or feed such as wood/crop residues (Fargione *et al*. 2009; Hartman et al. 2011).
- Use secondary wood sources that do not directly increase harvesting such as harvesting residues, industrial residues ad waste wood, animal/municipal wastes, cover crops and algae (Fargione *et al*. 2009).

- Use native species rather than introduced species and/or row crops or trees. This increases habitat heterogeneity and results in increased avian and insect biodiversity (Murray and Best 2003, Fargione *et al*. 2009, Fargione *et al*. 2010, Hartman 2011, Robertson *et al*. 2011).
- Use rotational or strip harvesting to improve species diversity as well crop rotation and well-managed agroforestry. Examples can be found for improvement of biodiversity of migratory bird species in switchgrass fields by providing both tallgrass and shortgrass habitats (Murray and Best 2003, Roth *et al*. 2005, Bies *et al*. 2006).
- Target biomass production to already degraded cropland and avoid converting native habitat to biofuel production fields (Fargione *et al*. 2010).
- Use of habitat corridor to maintain or increase connectivity and reduce fragmentation.
- Assess and implement no-go areas for biomass harvesting important for biodiversity and wildlife such as peatlands, wetlands and high conservation value forest (Fargione *et al*. 2010).
- Use biomass from landscape or habitat management that support efforts to maintain or improve habitats and biodiversity such as cuttings in grass lands, hedgerows, pruning (Fargione *et al*. 2009).
- Enforcing appropriate land and forest governance.

3.4 Pre-construction assessment and pre- and post-construction monitoring

The construction of bioenergy installations is likely to have similar effects for migratory species to other types of similar developments. This could include, amongst others, habitat loss, attraction or disturbance and direct mortality. Below we detail important points relating specifically to bioenergy. For general information on assessment and monitoring we refer to the general guidelines and review report.

Population surveys are critical in forming a basis of understanding of how biomass fuel cultivation can affect migratory species, primarily birds and terrestrial mammals. Ideally, population-based studies should be carried out for species in habitats proposed for conversation to biomass cultivation and how diversity and abundance of bird and mammal species changes with changing habitat, as well as seasonally based on crop harvest times. For areas where biomass production is proposed, surveys should assess the value of existing habitats for migratory species and any potential effects from changes in land use. Key habitats for migrant species, such as areas of conservation concern and endangered habitats should be identified, as well as effects of changes in crop regimes for existing agricultural land.

Surveys in cultivation areas should also be conducted pre- and post-harvest to identify changes in bird and mammal populations under different conditions of food and cover availability. Surveys should also be timed to coincide with different periods in the annual species lifecycle, specifically migration, breeding, and overwintering.

Ideally, population studies together with assessment of other environmental impacts should be conducted on areas planned for biomass production to avoid the conversion of native prairies, grasslands or forests into biofuel cultivation areas. Surveys should quantify the diversity and abundance of migratory species, as well as identify whether the area hosts any threatened or endangered species. These types of surveys should inform siting decisions for biomass production and harvesting areas, with areas of impact being those that provide the least valuable habitat to migratory birds, mammals, and rare species.

Surveys conducted in active biomass cultivation and harvesting areas can serve to identify whether management actions could increase the value of the habitat for migratory birds or mammals. To achieve this goal, prudent management actions could include those discussed in the section above.

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

3.5 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidance; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

1) Fargione, J. E., T. R. Cooper, D. J. Flaspohler, J. Hill, C. Lehman, T. McCoy, S. McLeod, E. J. Nelson, K. S. Oberhauser, and D. Tilman. 2009. Bioenergy and wildlife: threats and opportunities for grassland conservation. BioScience 59(9):767-77.
2) Fargione, J. E., R. J. Plevin, and J. D. Hill. 2010. The ecological impact of biofuels. Annual Review of Ecology, Evolution, and Systematics. 41:351-77.
3) GBEP 2011. The Global Bioenergy Partnership Sustainability Indicators for Bioenergy First edition http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf
4) Köppen, S., S. Markwardt, and H. Fehrenbach. 2013. Biofuels Screening Toolkit: Guidelines for Decision Makers.
5) ILUC 2012. Indirect Land Use Change (ILUC) http://europa.eu/rapid/press-release_MEMO-12-787_en.htm
6) National Wildlife Federation. 2013. Perennial Herbaceous Biomass Production and Harvest in the Prairie Pothole Region of the Northern Great Plains: Best Management Guidelines for Achieve Sustainability of Wildlife Resources.
7) The Heinz Center and The Pinchot Institute. 2009. Ensuring Forest Sustainability in the Development of Wood Biofuels and Bioenergy: Implications for Federal and States Policies.

8) UNEP/GEF/UNIDO for biofuels, see: http://www.unido.org/fileadmin/user_media_upgrade/What_we_do/Topics/Energy_access/Guidelines_for_Decision_Makers__FINAL_WEB_20022014.pdf

3.6 Literature

Andrade, R. M. T. de and A. Miccolis. 2010. Biodiesel in the Amazon. ICRAF Working Paper no. 113. Nairobi, Kenya: World Agroforestry Centre.

Bies, L. 2006. The Biofuels Explosion: Is Green Energy Good for Wildlife? Wildlife Society Bulletin 34(4):1203-05.

Cook, J. H., J. Beyea, and K. H. Keeler. 1991. Potential impacts of biomass production in the United States on biological diversity. Annual Review of Energy and the Environment 16:401-31.

de Carvalho, C.M. 2011. Strategic Environmental Assessment for Sustainable Expansion of Palm Oil Biofuels in Brazilian North Region. Energy & Environment. 22(5):565-76.

Fargione, J. E., T. R. Cooper, D. J. Flaspohler, J. Hill, C. Lehman, T. McCoy, S. McLeod, E. J. Nelson, K. S. Oberhauser, and D. Tilman. 2009. Bioenergy and wildlife: threats and opportunities for grassland conservation. BioScience 59(9):767-77.

Fargione, J. E., R. J. Plevin, and J. D. Hill. 2010. The ecological impact of biofuels. Annual Review of Ecology, Evolution, and Systematics. 41:351-77.

Finnan, J., Styles, D., Fitzgerald, J., Connolly, J. and Donnelly, A. (2012), Using a Strategic Environmental Assessment framework to quantify the environmental impact of bioenergy plans. GCB Bioenergy, 4: 311–329. doi: 10.1111/j.1757-1707.2011.01143.x

Hartman, J. C., J. B. Nippert, R. A. Orozco, C. J. Springer. 2011. Potential ecological impacts of switchgrass (Panicum virgatum L.) biofuel cultivation in the Central Great Plains, USA. Biomass and Bioenergy 35:3415-21.

Lapola, D. M., R. Schaldach, J. Alcamo, A. Bondeau, J. Koch, C. Koelking, and J. A. Priess. 2010. Indirect land-use changes can overcome carbon savings from biofuels in Brazil. PNAS 107(8):3388-3393.

Murray, L. D. and L. B. Best. 2003. Short-term bird response to harvesting switchgrass for biomass in Iowa. The Journal of Wildlife Management 67(3):611-21.

Robertson, B. A., P. J. Doran, E. R. Loomis, J. R. Robertson, and D. W. Schemske. 2011. Avian use of perennial biomass feedstocks as post-breeding and migratory stopover habitat. PLoS ONE 6(3):e16941.

Roth, A. M., D. W. Sample, C. A. Ribic, L. Paine, D. J. Undersander, and G. A. Bartelt. 2005. Grassland bird response to harvesting switchgrass as a biomass energy crop. Biomass and Bioenergy 28:490-498.

4 Geothermal energy

4.1 Main impacts

The various geothermal resource technologies differ in many respects, but they raise a common set of ecological issues concerning migratory species and their ecological systems. The main potential impacts of development and deployment of geothermal energy technologies on migratory species are summarized below for the construction, operational and decommissioning phases of projects. For a detailed description of the impacts of geothermal energy developments on migratory species we refer to the review of Van der Winden *et al*. (2014).

Construction and decommissioning

- Habitat loss for birds and mammals due to construction of geothermal power plants and infrastructure.
- Habitat degradation for birds, mammals and fish due to effects on surface water quality (emission of wastes).
- Habitat fragmentation for birds and mammals due to infrastructures and other structures (fences, buildings *etc*.).
- Disturbance of birds and mammals due to construction activities.
- Mortality of birds and mammals due to vehicle strikes.

Operation

- Disturbance of birds and mammals due to noise, light and thermal disturbance, and site infrastructure.
- Habitat degradation for birds, mammals and fish due to effects on surface water quality (emission of wastes), temperature and quantity (abstraction of water).

4.2 Legislation, policy and SEA and EIA procedures

For a general description of legislation, policy and the importance of and guidelines for Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) we refer to section 2.2.

Legislation and Policy

The institutional framework, legislation and legal constraints are borderlines to delimit development of geothermal deployment, especially in view of protection of migratory species. There is no legislation or policy specific for the development of geothermal energy technology and wildlife (migratory species). The legislative and regulatory framework for geothermal energy on a global scale and even within for instance the EU (http://geodh.eu/wp-content/uploads/2012/11/K4RES-H_Geothermal_Regulations.pdf) is very diverse. The relevant national legislation is spread throughout the mining, energy, environmental, water management and geological acts, sometimes in a contradictory way.

There are several reports presenting proposals for improving the regulatory framework for geothermal electricity in general, *e.g.* http://www.geoelec.eu/wp-content/uploads/2011/09/D4.1-Report-on-Geothermal-Regulations.pdf and http://www.geoelec.eu/wp-content/uploads/2013/11/D6.2-Final-Report.pdf.

Strategic Environmental Assessments

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. SEAs on large spatial scales can help to detect and avoid severe environmental impacts of geothermal energy developments. Although some countries have developed SEAs to address renewable energy development, these are rarely specific to geothermal energy. Some examples, without a special focus on migratory species, of general strategic geothermal planning are described in Box 4.1.

Box 4.1 Examples of strategic geothermal planning

USA: The United States, which possesses the world's largest installed geothermal energy capacity (Geothermal Energy Association 2013), has developed a Programmatic Environmental Impact Statement (PEIS) for Geothermal Leasing (BLM and USFS 2008) for federal lands in the western portion of the country. The PEIS evaluated various alternatives for allocating lands as being closed or available for leasing and analysed stipulations to protect sensitive resources. The PEIS also described the proposed amendments for federal land use plans to adopt recommended allocations, stipulations, procedures, and best management practices. http://permanent.access.gpo.gov/LPS123922/LPS123922/www.blm.gov/wo/st/en/prog/energy/geothermal/geothermal_nationwide/Documents/Final_PEIS.html

Peru: The Master Plan for Development of Geothermal Energy in Peru was developed on behalf of the Peruvian Ministry of Energy and Mines (Japan International Co-operation Agency 2013). This plan does not offer an explicit assessment of the environmental impacts of geothermal energy development in Peru. However, it does take into consideration minimization of deleterious environmental impacts by identifying environmentally sensitive areas. It also identifies areas for improvement, such as training of government agency staff in the environmental impact assessment process for geothermal energy projects.

Iceland: The Icelandic Government decided in 1997 to develop a Master Plan for all potential power projects in geothermal (and hydro) energy. All proposed projects should be evaluated and categorized on various aspects but also on the basis of the impact that the power developments would have on the environment. The work was organized by a steering committee of 16 members and some 50 experts were nominated for four working groups (including wildlife experts). It was not supposed to go into the details required for environmental impact assessment (EIA), but still finding those projects that are best suited for developments based on energy production, economy and protection of the nature. Experts assessed the potential impacts of the various proposed power projects on flora and fauna. They reviewed existing data for each proposed project and divided them by quality into three categories; good (A), fair (B) and unsatisfactory (C) and suggested several data collection tasks in order to improve the knowledge base for the project areas. To rank the proposed projects the working group considered several ways of carrying out the evaluation and selected eventually a three-step procedure using multi criteria analysis. The first step was to assess site values, then in the second step the impact of the development was evaluated and finally in the third step the proposed projects were ranked from worst to best choice from an environmental-cultural heritage point of view using analytical hierarchical process using site values and predicted impacts. http://www.rammaaaetlun.is/english

Box 4.2 Example of SEA for geothermal technology deployment

USA: The United States Departments of Interior and Agriculture have issued a Final Programmatic Environmental Impact Statement (PEIS) (in other countries known as SEA) for Geothermal Leasing in the Western United States (2008) that outlines the general impacts and environmental concerns, including impacts to migratory wildlife, from geothermal energy development. The principles outlined in the PEIS can be applied generally to any SEA for future geothermal energy development.

http://permanent.access.gpo.gov/LPS123922/LPS123922/www.blm.gov/wo/st/en/prog/energy/geothermal/geothermal_nationwide/Documents/Final_PEIS.html

Environmental Impact Assessments (EIAs)

In the context of migratory species, EIAs for geothermal energy developments should specifically focus on:

- Migratory species: birds, mammals and fish.
- The function and importance of the impact area for migrating species: are there frequently used movement paths, exceptional concentrations of migratory species, important breeding or feeding grounds of migratory species or spatial bottlenecks (narrow corridors).
- Main impacts of geothermal energy technology deployment on migratory species: see paragraph 4.1.
- Measures to avoid, minimize or reduce significant adverse impacts of geothermal energy technology deployment on migratory species: see paragraph 4.3

4.3 Best practice of mitigation

To determine whether the impact can be avoided or mitigated, what action can be taken, how effective the mitigation measure will be, and the cost-effectiveness of the measures, project- and site-specific factors must be evaluated. A final set of mitigation measures for the project in consultation with the appropriate resource management agencies and stakeholders should be developed. These consultations should be conducted early in the project development process and prior to final project siting and design. This section discusses mitigation measures, based on the discussion of impacts described in §4.1. (http://teeic.indianaffairs.gov/er/geothermal/mitigation/eco/index.htm).

<u>Siting</u>

- Avoid development in sensitive or priority migratory habitat by conduction pre-development site-specific assessments of potential migratory species to be affected and the importance of the area to those species.

<u>Design</u>

- Design pipeline corridors in an appropriate way. Avoid blocking animal migration routes, by burying pipes underground or elevating them to allow free movement of animals.
- Minimize habitat loss by directional drilling techniques.
- Avoid wildlife drinking geothermal wastewater by separating geothermal fluids isolated in securely fenced high-density polyethylene (HDPE) lined sump ponds, prior to disposal through re-injection into the reservoir.
- Supply potable water to wildlife at various points so that they are not tempted to drink geothermal wastewater particularly during dry weather conditions.
- Closing off waste brine conditioning ponds to prevent wildlife coming into direct contact with water.
- Employment of injection technology at geothermal reservoir wells to reduce land subsidence and the contamination of local water bodies with wastewater.
- Cooling by re-injection of water and / or recycling.

Mitigation in operational phase

- Avoid wastage of water resources and harvest water during rainfall.

4.4 Pre-construction assessment and pre- and post-construction monitoring

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

Pre-construction assessment and monitoring / Baseline study

Monitoring efforts should be focused on siting of geothermal energy facilities with regard to land use by migratory wildlife species (birds, mammals, fish) especially those defined as threatened under the IUCN Red List or that are referenced under local, regional or national conservation priorities. Determine the species at risk and gather information on which the prediction of the extent of the impact on birds can be based. Pre-construction assessment should involve studies of the abundance, dispersal, activity and movement patterns of migratory species. The results of general presence/absence and diversity and abundance surveys of migratory wildlife should inform siting decisions of geothermal energy facilities. The monitoring period should at least include all stages of the life cycle of the relevant species, which generally means a minimum monitoring period of 12 months.

Post-construction monitoring

- Monitoring of populations of relevant migratory fauna
- Monitoring of water bodies (quantity, quality and temperature, flows) that are impacted (by abstraction and / or waste)

4.5 Summary of existing guidelines and tools

Guidance on measures for geothermal energy to avoid, mitigate and compensate impacts on (migratory) wildlife is limited. For useful guidance, reference is made to:

Bureau of Land Management and United States Forest Service. 2008. Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States.

http://teeic.indianaffairs.gov/er/ geothermal/mitigation/ eco/index.html

4.6 Literature

Abbasi, S. A. and N. Abbasi. 2000. The likely adverse environmental impacts of renewable energy sources. Applied Energy 65:121-144.

Bureau of Land Management and United States Forest Service. 2008. Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States.

[GEA] Geothermal Energy Association. 2012. Geothermal: International Market Overview Report.

Japan International Cooperation Agency. 2013. Master plan for the development of geothermal energy in Peru. Final Report. Prepared for the Peruvian Ministry of Energy and Mines.

Kagel, A., D. Bates, and K. Gawell. 2007. A guide to geothermal energy and the environment. Geothermal Energy Association.

Matek, B. 2013. Geothermal Power: International Market Overview. Washington, D.C.: Geothermal Energy Association.

Northrup, J. M. And G. Wittemyer. 2012. Characterising the impacts of emerging energy development on wildlife, with an eye towards mitigation. Ecology Letters 16:112-125.3.0 Hydropower.

5 Hydropower

5.1 Main impacts

The potential impacts of conventional storage hydropower energy on ecological systems and migratory species include:

- mortality of migrating aquatic organisms, such as fish in the turbines of operating hydro power-stations,
- changes in hydrological regimes on affected waterways and floodplains.
- habitat loss through disturbance or displacement arising from reservoir creation,
- in-stream barriers to the migration of aquatic organisms, such as fish,
- poor water quality related to changes in flow regimes,
- sedimentation in waterways upstream of hydro energy facilities,

Migratory fish, birds, mammals and reptiles have the potential to be affected by both storage and run-of-the-river hydropower. Greater impacts generally occur from storage hydropower as projects are often larger scale and have greater influences on habitats. The main potential impacts of development and deployment of hydropower energy technologies on migratory species are summarized below for the construction, operational and decommissioning phases of projects. For a detailed description of the impacts of hydropower energy developments on migratory species we refer to the review of Van der Winden *et al*. (2014).

Construction and decommissioning

- Mortality of fish, birds and reptiles through poaching, potential chemical spills and drainage of wetlands.
- Habitat loss for fish, birds, mammals and reptiles.
- Obstruction of movement for fish, aquatic mammals and freshwater turtles.
- Habitat degradation for fish and freshwater turtles through changes in hydrology to areas downstream and upstream.
- Habitat alteration for fish through changes in erosion and sedimentation downstream.

Operation

- Direct mortality of fish and potentially turtles from turbines as well as changed water pressure as organisms pass through hydro power stations.
- Loss of shallow, fast flowing riverine habitats, riparian edges and fish spawning areas where hydroelectric dams are constructed.
- Habitat gain through the creation of large, deep water reservoirs for water storage.
- Obstruction of movement by physical structure built across migration pathways for fish, aquatic mammals and freshwater turtles. Some amelioration through provision of fish ladders and lifts may be possible.
- Seasonal hydrological and water temperature changes, including loss of fish spawning sites and spawning temperature triggers.
- Habitat degradation and loss resulting from altered water flows, leading to direct impact on fish and waterbirds, as well as impacts on the prey of fish, turtles, aquatic mammals and waterbirds. Alteration also occur to riparian vegetation and sandbanks

changing the geomorphology of the lower reaches of rivers, leading to a loss of nesting opportunities for fish, birds, aquatic mammals and reptiles (*e.g.* turtle breeding sites).

- Proliferation of alien species.
- Accumulation of toxic run-off from catchments in hydroelectric reservoirs, leading to increased bio-accumulation in organisms that use the reservoir.
- Reduced flooding rates downstream, leading to less frequent fish, turtle and waterbird breeding events.

For impacts and guidelines on tidal barrages referenced is made to chapter 6 (Ocean energy).

5.2 Legislation, policy and SEA and EIA procedures

Legislation and policy

The legislation and policy in hydropower development and maintenance in relation to wildlife vary substantially among different continents and countries. Some examples of directives and policies are provided hereafter to underline this.

In Europe, the Water Framework Directive (WDF) of 2000 provides a legislative approach to managing and protecting water based on natural geographical and hydrological formations (river basins). One of the objectives of the WFD is that water will achieve good ecological and chemical status, to protect human health, water supply, natural ecosystems and biodiversity, which includes migratory species. For hydropower developments, the implementation of articles 5 and 6 of the WFD includes the review of environmental impacts of human activity and guidelines for monitoring of surface water status.

The WFD is a framework for EU water policy and is complemented by other legislation regulating specific aspects of water use listed below.

- The Groundwater Directive (2006).
- The Environmental Quality Standards Directive (2008).
- Two Commission Decisions (2005 and 2008) on ecological status established a register of almost 1,500 sites included in a calibration exercise to allow for comparison of different countries' environmental standards, and published the results. This included waterway and related ecological standards.

In the U.S., a total of 29 States, the Districts of Columbia and Puerto Rico have Renewable Portfolio Standards (RPSs) as of March 2012. Each State sets its own targets and designates which technologies will be eligible. While hydropower is recognized as a fully renewable resource, its inclusion as an eligible technology varies from State to State. Where RPSs include hydropower, there are often conditions on size, location, or age that limit its eligibility. However, there has been a trend in recent years towards more inclusive treatment of hydropower. In January 2013, the Hydropower Regulatory Efficiency Act was unanimously passed as a policy to promote the growth of mini and run-of-river hydropower through streamlining the permitting process for such types of hydropower. Also in January 2013, the American Taxpayer Relief Act included a one-year extension of the Production Tax Credit (PTC) for renewable energy development. Environmental concerns related to fish passage have led to the removal of some dams in the US. This often involves deciding on trade-offs between ecosystem restoration and the current socio-economic benefits of the projects.

Several countries in Latin America are undertaking assessments of hydropower potential and policy reforms. Paraguay, for example, undertook an assessment of national hydropower potential throughout 2012 to identify project locations. Argentina has completed its 2030 Plan including an Energy Policy Main Axis focusing on hydropower and nuclear with the goal to reduce gas in the electricity market from 52% to 30%. Similarly Chile published its National Energy Strategy 2012-2030, which intends to increase the market share of hydropower from the current 34% to 48%.

Strategic Environmental Assessment (SEA)

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. An SEA can be undertaken for both project implementation and project operation, and include evaluation of associated works and infrastructure, scoping of cumulative impacts, the role and capacity of third parties, and impacts associated with primary suppliers, using appropriate expertise and with no significant gaps (International Hydropower Association 2010). The World Commission on Dams suggests criteria and guidelines for applying the strategic priorities for proposed dams. This includes five principal measures to respond to ecosystem impacts:

- measures that avoid the anticipated adverse effects of a large dam through the selection of alternative projects;
- measures to minimize impacts by altering project design features once a dam is decided upon;
- mitigation measures that are incorporated into a new or existing dam design or operating regime in order to reduce ecosystem impacts to acceptable levels;
- measures that compensate for unavoidable residual effects by enhancing ecosystem attributes in watersheds above dams or at other sites;
- and measures to restore aspects of riverine ecosystems.

To ensure the success of mitigation measures is maximised, conditions include:

- a good information base and competent and knowledgeable staff available to formulate complex choices for decision-makers;
- an adequate legal framework and compliance mechanisms;
- a co-operative process with the design team and stakeholders;
- monitoring of feedback and evaluation of mitigation effectiveness; and
- adequate financial and institutional resources.

Baseline data must be collected to establish and document the pre-project condition of the affected environment, against which post-project changes can be compared. For hydropower developments the SEA process is described in detail in International Hydropower Association (2010). Some examples of strategic hydropower planning are described in Box 5.1

Box 5.1 Examples of strategic hydropower planning

Mekong River: The Mekong River Commission is an inter-governmental river basin organization that provides the institutional framework to implement the 1995 Mekong Agreement for regional cooperation in the Mekong Basin. The SEA seeks to identify the potential opportunities and risks by assessing alternative Mekong hydropower development strategies (International Centre for Environmental Management 2010).

Vietnam: The International Centre for the Environmental Management prepared a pilot SEA that focused on the potential effects of planned hydropower on biodiversity. The pilot provided a methodology and set of tools for assessing biodiversity effects of hydropower at the strategic level. It also identified geographic areas and groups of projects in the 6th PDP, which require more intensive appraisal and mitigation to ensure their sustainability and minimize their negative impacts on biodiversity and on the economy (International Centre for the Environmental Management 2007).

United States: The United States Department of Energy commissioned an assessment of energy potential from new stream-reach hydroelectric development (Kao *et al.* 2014). This assessment used key technical, environmental and socioeconomic characteristics to identify opportunities for new hydropower development in 3 million streams. The datasets and tools developed through this assessment are designed to be flexible so that they can be customized to meet the analytical needs of individual stakeholders.

<u>Environmental Impact Assessment (EIA)</u>

An Environmental Impact Assessment (EIA) is important to identify both the impacts a specific hydropower development will have on the local environment and mitigation strategies. In the context of migratory species, EIAs for hydropower developments should specifically focus on the importance of the area for migrating fish as well as also aquatic mammals and freshwater turtles. The impacts on the migratory pathways of diadromous fish species should especially be examined, and the EIA should include a plan for mitigating the impacts to migratory fish species and other migratory wildlife that will be affected by the deployment of the technology. In addition, the possible implications of altered flow regimes (often driven by varying power demand) for flooding and wetland filling downstream of hydropower dams must be investigated as this can affect significant breeding concentrations of both migratory fish and birds. The possible barrier effects and detrimental effects on habitats of migratory species should be considered. Sample guidelines have been provided by Energy Sector Management Assistance Program (2012).

The EIA should also address the impacts in relation to habitat loss and reduction in quantity, quality and timing of water flows and potential impacts this may have on migratory species, such as the impact of dams in the Inner Niger Delta on Palearctic migrants. Many habitat types on which migratory species rely are only occupied for a specific period in the annual life cycle for *e.g.* winter or breeding. The EIA must be designed to integrate these decisions.

Box 5.2. Examples of EIA hydropower planning

Americas: The construction of new hydroelectric dams in North America has stalled in recent decades and many older dams have been or are being decommissioned. Conversely, this renewable energy technology is growing in Latin America, particularly in the Amazon River basin, which has enormous potential for hydropower development. In Brazil, EIAs are required by law for projects that may have a negative impact on wildlife, including hydroelectric power facilities. Robust and defendable EIAs for hydropower projects should include an analysis of alternatives to the proposed project, including a "no-action" alternative in which there is no development, as well as an analysis of the existing environmental resources and the expected impacts to those resources as a result of the project. There are many examples of EIAs that have been conducted for hydropower facilities in the United States, which use this model. EIAs for hydropower facilities should focus on impacts to aquatic resources in the affected river system and terrestrial resources that will be affected due to permanent flooding or submersion of formerly upland habitats. The impacts on the migratory pathways of diadromous fish species should especially be examined, and the EIA should include a plan for mitigating the impacts to migratory fish species and other migratory wildlife that will be affected by the deployment of the technology.

5.3 Best practice of mitigation

Planning

Planning for the construction of hydroelectricity dams needs an integrated approach, taking into account economic, social and environmental considerations. The World Commission on Dams, a non-government organisation with a special interest in this issue has developed a document on the subject (WCD 2000). This document provides an example of an overarching, integrated approach to dam feasibility studies. Chapter 9 in particular suggests number of steps to provide better economic, social and environmental outcomes in planning and implementing dam projects, including those built for hydroelectric generation. These steps also include criteria on whether particular integrated outcomes are likely to be achieved. The steps are summarized below.

- Needs assessment – is there a valid requirement for a hydroelectric dam?
- Thoroughly investigate options – is the proposal the most economically, socially and environmentally sustainable means of achieving the requirement?
- Detailed project preparation – Are all approvals and agreements in place before construction tenders are called for?
- Project implementation – Does the project comply with all approvals and agreements before it commences operation?
- Project operation – Are there procedures in place to vary operations in an adaptive way in response to monitored outcomes?

The steps described above are an excellent framework and represent the usual steps any development project has to pass through if it is to be successful. Integrating environmental matters into each step and using criteria for measuring success at each step of the project planning process are vital to ensure hydroelectricity generation can proceed with acceptable environmental outcomes and in particular acceptable outcomes for migratory species.

Siting

Impacts to habitat due to siting will vary greatly depending on the location of the hydropower development. Hydropower projects have the potential to fragment and transform aquatic and terrestrial ecosystems, alter downstream flows and alter natural habitats, migratory patterns, floodplain ecosystems, downstream fisheries and natural flood cycles that may affect biodiversity. The most effective way to avoid adverse effects of hydropower developments on migratory species of all taxa is to plan hydropower energy away from critical or sensitive habitats and priority areas for conservation (such as IBAs and KBAs), adjacent to or downstream from the development. Large-scale facilities have the potential to eliminate unique valley bottom habitats, which may represent critical habitat for threatened species (Office of Investment Policy, 2012).

Mitigation

Construction and decommissioning

There are many mitigation measures to reduce or avoid impacts on migratory species from the construction of hydropower developments. The following are some examples.

- Not placing large dams on the main-stem of a river system thereby permitting large-scale migration of river-dependent fauna.
- Avoid siting in areas characterized by high erosion rates.
- Establishment and maintenance of minimum flows in the river to meet downstream needs of the ecosystem and to provide for the migration needs of aquatic organisms
- Consider and design effective fishways or fish ladders to allow passage of migratory fish species past dams.
- Improvements in turbine, spillway, and over flow design have proven to be highly successful in minimizing mortality in and injury to fish and other aquatic organism mortality and injury.
- Consider restoring or mitigating the impacts of reservoirs on downstream ecosystems through managed floods and a programme of enhanced 'quantity, quality and timing of water flows, with these flows considered of equal status to power generation and irrigation water flows. Consideration of the project's area of influence is crucial in the success of mitigation measures.
- Periodic releases from large reservoirs may be useful in increasing flows of both sediment and nutrient to downstream habitats in riverine environments.
- Compensate for terrestrial habitat eliminated by reservoir creation by establishing managed habitat elsewhere (*i.e.* environmental offsets).
- Time construction to avoid sensitive periods (*e.g.* during key breeding and migration seasons for aquatic organisms).

As a specific example, a construction period was limited to four-months of the year during which large local raptors were not nesting in order to protect their breeding activities (Okutadami & Otori Expansion Hydropower Project, Japan).

For detailed guidelines for the mitigation of the construction and decommissioning of hydropower facilities refer to: International Energy Agency 2006a, 2006b, 2012, and Office of Investment 2012.

Operation

The following has been adapted from International Energy Agency 2006b.

Operational phase mitigation focuses on key issues, with those most relevant to migratory species including:

- Biological diversity
- Hydrological regimes
- Fish migration and river navigation
- Water quality
- Reservoir impoundment

Biological diversity – The measures below are critical to ensure that the impacts of hydropower development on biological diversity are mitigated.

- Understanding the influence of the project on the surrounding environment and selection and implementation of appropriate conservation measures based on the EIA
- Regeneration of vegetation by planting
- Conservation of a river ecosystem by maintaining minimum flow levels to mimic natural hydrological regimes
- Implementing measures to prevent invasion of alien species throughout the duration of projects
- Monitoring measures after they are implemented to evaluate their effectiveness and adaptive management informed by monitoring results.

Hydrological regimes - The measures below are important to mitigate the potentially detrimental impacts of changes in hydrological regime.

- Maintaining river flow rates at levels needed to maintain the ecological function of the river and its associated habitats, many of which may be important for migratory aquatic animals.
- Increase flow rates at fish passageway entry points to deter downstream fish passage through turbines and to encourage downward migration (Fjelstad *et al.* 2012).
- Reservoir management that considers the requirements of any migratory species that utilize the habitats created by the reservoir (*e.g.* seasonal passage of fish or waterbirds)
- The judicious use of weirs, designed not to obstruct fish passage, to create areas of permanent water in rivers affected by reduced flows from the operation of hydropower dams, thereby creating refuge habitat at critical times of year or during drought for migratory and other aquatic species.
- Monitoring after the measures are undertaken to evaluate their effectiveness and adaptive management in response to monitoring findings.

Fish migration and river navigation - The measures below are expected to promote fish migration and reduce mortality rates and damage to fish which pass through hydraulic turbines or spillways.

- Installation of artificial fish passageways to reconnect fragmented rivers and restore fish movements. Installation and monitoring should account for both upstream and downstream migration movements, species' migration routes, river flow rates and discharge before and after a facility has been built, spatial distribution of habitats, behaviour of species, population recruitment dynamics, and life history stages (Agostinho *et al*. 2011, Godinho and Kynard 2009, and Pompeu *et al*. 2012).
- Installation of measures to attract and direct fish away from the intake to hydro power stations (acoustic type, mercury lamp, sodium lamp).
- When designing fish passageways, fish biologists and engineers should collaborate to solve fish passage problems (Godinho and Kynard 2009).

Water quality - The following are to be implemented to improve water quality in reservoirs and downstream areas.

- Temperature control considering the growth of fish by installing selective water intake facilities
- Reduction in water turbidity by selecting the operation of dams and constructing bypass tunnels
- Eliminate the occurrence of abnormal odour or taste of the water in reservoirs by installing full thickness aeration and circulation facilities.

Reservoir impoundment - The measures below can mitigate environmental impacts relating to impoundment of reservoirs.

- Reductions in the scale of regulating reservoir levels and preservation of wetlands by maintaining appropriate water levels in reservoirs
- Environmental research to explore the feasibility and consequences of alternative reservoir water level regimes, with managed levels reflecting optimum environmental outcomes.

Recommendations can be made to improve existing hydropower facilities and design new facilities to account for and minimize injury and mortality related to pressure changes in migratory fish during turbine passage (Brown *et al*. 2012).

5.4 Pre-construction assessment and pre- and post-construction monitoring

Assessment and monitoring includes the collection, analysis, interpretation and reporting of specific physical and biological information. Pre-construction monitoring is essential to collate data on the ecology of an affected area to provide baseline data and is part of the planning process. This baseline data can be used to undertake an EIA and generate mitigation measures for the project. Post-construction monitoring should be undertaken in a way that allows the results to be compared to baseline data and allow assessment as to the effectiveness of mitigation measures. This should cover all species and groups that could potentially be affected by the development.

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

In designing project environmental monitoring programmes, it is vital to consider the scale of the affected area. In the case of dams, the actual site of the dam and reservoir are clearly affected but so too are the downstream reaches of waterways and associated riparian zones and floodplains because of the impact of the dam on otherwise natural flow and flood regimes. These habitats are often vital for migratory species, including significant populations and critical habitats (e.g. breeding and stopover sites) that may permanently disappear unless adaptive monitoring and management of flow regimes are informed by appropriately scaled monitoring. For hydro -electricity generating dams, this must include all downstream, waterway dependent ecosystems.

Pre-construction assessment and monitoring / Baseline study

Fish – Monitoring should aim to collate information that is needed to predict the environmental impacts of the hydropower development and provide the necessary baseline data for long-term monitoring. Pre-construction monitoring should be undertaken over a minimum two-year period and involve studies on the following:

- Water quality
- Aquatic habitat
- Aquatic macro-invertebrates
- Fish communities (abundance and behaviour)
- Fish breeding areas (upstream from hydropower facility) and non-breeding areas (up- or downstream of facility)

Physical Environmental Monitoring – A range of physical attributes of waterways should be monitored and/or modelled from historical catchment and climate data as part of baseline investigations for assessing environmental impacts and for monitoring the impacts of the operational phase of hydropower projects. These include:

- Water depth and velocity
- Sediment parameters
- Shoreline erosion and, where relevant, peat breakdown
- Sediment deposition upstream and downstream of the hydropower facility

- Dissolved oxygen and water temperature, including pre-construction and operational seasonal patterns
- Total dissolved gas pressure both upstream and downstream of the hydropower facility.

Post-construction monitoring

Fish – Post-construction monitoring of fish should continue for at least several years, and ideally continually. It should use the same methods, sites and timing of sampling as the pre-construction monitoring. In this way, a monitoring programme will be integrated and consistent, providing a more efficient, comparable and statistically powerful assessment of project impacts.

Guidelines

For detailed guidelines on aquatic monitoring of hydropower developments refer to Lewis *et. al.* (2013). Furthermore it should be stressed that the standards derived by the "World Commission on Dams" framework need to be applied.

5.5 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidance; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

1) Energy Sector Management Assistance Program, 2012. Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey. Ankara, Turkey.
2) Gough, P., P. Philipsen, P.P. Schollema & H. Wanningen, 2012. From sea to source; International guidance for the restoration of fish migration highways.
3) International Centre for Environmental Management, 2007. Pilot Strategic Environmental Assessment in the Hydropower Sub-sector, Vietnam. Final Report: Biodiversity Impacts of the hydropower components of the 6th Power Development Plan. Prepare for The World Bank, MONRE, MOI & EVN, Hanoi, Vietnam.
4) International Centre for Environmental Management, 2010. MRC Strategic Environmental Assessment (SEA) of hydropower on the Mekong mainstream, Hanoi, Viet Nam.
5) International Energy Agency, 2006a. Implementing agreement for hydropower technologies and programmes - Annex III, Hydropower and environment: present context and guidelines for future actions, Volume I: Summary and recommendations.
6) International Energy Agency, 2006b. Implementing agreement for hydropower technologies and programmes - Annex VIII, Hydropower good practice: environmental mitigation measures and benefits. New Energy Foundation, Japan.
7) International Energy Agency, 2012. Technology Roadmap – Hydropower. International Energy Agency, Paris, France.
8) International Hydropower Association, 2010. Hydropower Sustainability Assessment Protocol.

9) Lewis, F.J.A., A.J. Harwood, C. Zyla, K.D. Ganshorn, and T. Hatfield. 2013. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88p.
10) Kumar, A., T. Schei, A. Ahenkorah, R. Caceres Rodriguez, J.-M. Devernay, M. Freitas, D. Hall, A. Killingtveit, Z. Liu, 2011: Hydropower. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlomer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
11) Office of Investment, 2012. Overseas Private Investment Corporation – Environmental Guidance – Renewable Energy – Hydropower.
12) World Commission on Dams framework, 2000: http://www.internationalrivers.org/resources/dams-and-development-a-new-framework-for-decision-making-3939 and http://www.internationalrivers.org/files/attached-files/world_commission_on_dams_final_ report.pdf
13) World Commission on Dams (2000) Dams and development: a new framework for decision making. Earthscan, London and Sterling VA.

5.6 Literature

Brown, R.S., B.D. Pfugrath, A.H. Colotelo, C.J. Brauner, T.J. Carlson, Z.D. Deng & A.G. Seaburg, 2012. Pathways of barotrauma in juvenile salmonids exposed to simulated hydroturbine passage: Boyle's law vs. Henry's law. Fisheries Research 121-122: 43-50. http://brauner-home.zoology.ubc.ca/files/2008/06/91.pdf.

6 Ocean energy

6.1 Main impacts

Development of ocean energy projects, which includes here wave, tidal and marine current power, has the potential to have an impact on migratory fish, sea turtles, birds, marine mammals, crustaceans and squid. Impacts to these species groups include habitat loss and degradation, mortality, physiological effects, and obstruction to movement. Besides affecting offshore environments, ocean energy developments can have consequences for intertidal areas and coastal areas, through barrages and control and associated structures that are sited on land. The main potential impacts of development and deployment of ocean energy technologies on migratory species are summarized below for the construction, operational and decommissioning phases of projects. For a detailed description of the impacts of ocean energy developments on migratory species we refer to the review of Van der Winden *et al*. (2014).

Construction and decommissioning

- Habitat loss for fish, sea turtles, marine mammals, and crustaceans and squid.
- Loss of inter-tidal habitats important for benthic species and especially birds.
- Habitat degradation for fish, sea turtles, birds, marine mammals, and crustaceans and squid.
- Direct mortality for birds, sea turtles, and marine mammals through entanglement or collision with structures.
- Disturbance during pile driving or from turbines mainly affecting marine mammals.

Operation

- Direct mortality for fish, sea turtles, birds, and marine mammals through collision and entanglement.
- Habitat loss for fish, sea turtles, birds, and crustaceans and squid.
- Loss of intertidal habitats
- Habitat degradation for fish, sea turtles, birds, marine mammals, and crustaceans and squid.
- Obstruction for movement for fish, sea turtles, and marine mammals.

6.2 Legislation, policy and SEA and EIA procedures

Legislation and policy

Some countries with high potential for development of ocean energy technology have established ocean policies that identify overarching values, goals, and strategies for management and use of their ocean resources (UNESCO Intergovernmental Oceanographic Commission). These policy initiatives often include the goal of developing renewable ocean energy within the territorial waters of the country. See box 6.1 for examples of ocean policy initiatives for two countries with a high potential for renewable ocean energy development: Canada and the USA. Recommendations, guidelines and regulations regarding the effects on the environment of underwater noise have been prepared by many international forums, such as the European Commission, the U.S. Marine Mammal Commission, OSPAR, UNCLOS, CMS, ASCOBANS and the IWC.

In Europe the EU Habitats and Birds Directive and EU Water Framework provide essential protection instruments and possibilities for compensation and mitigation in legislation. See POSTNOTE nr 435, June 2013: Environmental impact of tidal barrages.

Box 6.1 Examples of marine wildlife legislation Americas

Canada's Oceans Act, passed in 1997, mandates that the national strategy of ocean use will be based on the principles of sustainable development and the integrated management of activities in coastal and marine waters. The Oceans Act calls for the Minister of Fisheries and Oceans to lead and facilitate the development of a national ocean management strategy, which includes development and deployment of renewable energy technology as well as the protection of the marine environment, presumably including migratory species and their habitats.

The United States established a National Ocean Policy in 2010 which provides a framework for a comprehensive and integrated ecosystem-based management approach to ocean policy. The National Ocean Policy Implementation Plan acknowledges the need to develop renewable ocean energy technologies and begin generating electricity from these sources, while at the same time protecting marine resources through the use of sound spatial planning and sustainable development.

Strategic Environmental Assessments (SEA)

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. SEAs for ocean energy development are an important tool in planning, deploying, and managing renewable ocean energy developments. SEAs should consider all facets of the environmental impacts of a network of utility-scale ocean energy technology deployments and provide a strategic vision and guidelines for assessing impacts to the environment before, during, and after construction of the project. SEAs should consider the cumulative effects of multiple ocean energy technology deployments in conjunction with other renewable and non-renewable energy developments in a given region. SEAs should also identify areas that are potentially suitable for ocean energy and tidal barrage technology deployment (pending the completion of an EIA, discussed below) and, because habitat loss is such a significant impact to migratory species, SEAs should protect areas that should not be developed due to the presence of significant natural resources, such as critical habitat for migratory wildlife. An example of two SEAs that were prepared in Canada, a country with a high potential for ocean energy development, are given in the box 6.2.

Box 6.2 examples for SEA energy potential Canada

Canada has a high ocean energy generation potential and in the mid-2000s the Nova Scotia Department of Energy commissioned a Strategic Environmental Assessment (SEA) for demonstration-scale and utility-scale tidal energy projects in the Bay of Fundy. The SEA included an analysis of the interactions between marine renewable energy technology and the environment, including migratory species, and how different phases of tidal energy technology deployment would probably impact the various aspects of the marine environment. As a follow-up to the Bay of Fundy SEA, a second SEA was commissioned by the Government of Nova Scotia for marine renewable energy in the Cape Breton coastal region. The background report to support the Cape Breton SEA was completed in 2012. The background report details the existing environmental conditions of the Cape Breton region, including the communities of migratory wildlife that are present in the area: sea birds, marine mammals, and migratory fish species to support future planning for ocean energy technology deployments in the region.

The United States Department of the Interior has issued a Final Programmatic Environmental Impact Statement (PEIS) for Alternative Energy Development and Production on the Outer Continental Shelf (2007) which outlines the existing ocean resources in the area proposed for development, provide an analysis of alternatives to the proposed project, outline the expected impacts to natural resources from the proposed project, and offer monitoring and mitigation strategies that will assist in minimizing impacts to migratory wildlife and their habitats. An example EIA for ocean energy development was prepared by the United States Department of the Interior in 2007. The Programmatic Environmental Impact Statement (PEIS) for Alternative Energy Development and Production on the Outer Continental Shelf identifies the general impacts and environmental concerns, including impacts to migratory marine wildlife, from renewable ocean energy development in the Atlantic and Pacific Oceans and the Gulf of Mexico. The principles outlined in the PEIS can be applied generally to any renewable ocean energy project around the world.

Environmental Impact Assessments (EIA)

Environmental Impact Assessments (EIAs) should be conducted as part of any renewable ocean or tidal energy development project that has the potential to impact migratory species or their habitats, including migratory birds, bats, marine mammals, sea turtles, fish, crustaceans and squid.

6.3 Best practice of mitigation

Planning and siting

- A thorough site selection and review process should be implemented to avoid locating the development in major migration corridors or sensitive habitats (Boehlert *et al*. 2008).
- Construction, maintenance, and decommissioning activities should be scheduled to avoid important migration periods when migratory species would potentially be in the area to reduce negative interactions with migratory wildlife.

Mitigation

- Minimize the use of slack or loose tether and anchor lines to reduce entanglement risk to species (Boehlert *et al*. 2008).

- Use observers on board vessels to inform temporary cessation of construction, maintenance, and decommissioning activities with the aim of avoiding disturbance to marine species in the work area, including sea turtles and marine mammals.
- Use noise-deflecting devices (*e.g*. bubble walls or baffles) around the work site during high-decibel generating phases of construction to avoid physiological impacts to marine mammals and sea turtles.
- Undersea cables within the ocean energy development array and at the landfall connection should be buried to depths within the sediment that will minimize or eliminate the impacts from EMF to sea turtles and marine mammals.
- There is limited evidence on the efficacy of mitigation but Very Low-Head (VLH) turbines showed some promising results in lowering fish mortality.
- There is no evidence for effective mitigation measurements of loss of intertidal habitats as a result of barrages.

6.4 Pre-construction assessment and pre- and post-construction monitoring

Pre- and post-construction assessment and monitoring is important in the planning, construction, and operation of ocean energy facilities. Additionally, undertaking monitoring during construction is an important element in mitigating impacts to marine migratory species. Along with offshore wind energy developments, monitoring during construction is likely essential for ocean energy facility. It is recommended to employ adaptive monitoring of new developments through the planning, construction, and operational phases through carefully designed protocols to inform similar and future projects being proposed (Witt *et al*. 2011, ORPC 2013).

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

Pre-construction assessment and monitoring studies should focus on diversity and abundance of marine migratory wildlife in the area of potential affect and habitat characterization of the area with respect to resources available for marine migratory wildlife. This baseline information should contribute to decisions on siting of ocean energy facilities, types of ocean energy technologies to be employed at a specific site, and appropriate mitigation measure to be used during and after construction. Pre-construction surveys for birds should involve studies of the diversity, abundance, dispersal, and activity of migratory bird species, especially those with a greater likelihood of being affected by the proposed project. This monitoring should involve all significant stages in the annual life cycle of migratory birds, including migration, breeding, and over-wintering. Pre-construction surveys for migratory marine species (including fish, sea turtles, marine mammals, squid, and crustaceans) should focus on studying the migration patterns from a geographical and temporal standpoint and whether the proposed project area provides critical resources for migratory marine species or hosts concentrations of these species at any time during the year.

Conducting monitoring during ocean energy facility construction can be a significant factor in avoiding impacts to migratory marine wildlife during active construction operations. Monitoring during construction should occur whenever there is a possibility that migratory marine species are expected to be in the project area during construction. Sea turtles and marine mammals are probably the two taxa of migratory marine wildlife that have the highest potential to be affected by construction activities, especially those that produce underwater noise. The auditory capacities of sea turtles and marine mammals can be damaged by loud undersea noises that can occur during marine construction activities, such as pile driving, drilling, blasting, or pounding. The extent to which these construction techniques are used at a project site should determine the intensity of monitoring for sea turtles and marine mammals during construction. When sea turtles or marine mammals are detected in the vicinity of noise-generating activities with the potential to cause auditory harm, mitigation measures should be employed to avoid this impact.

Post-construction monitoring can be used to evaluate the effectiveness of mitigating measures and compare predicted effects with actual outcomes. If necessary and feasible, adjustments in the operation of ocean energy facilities can be made to avoid impacts to migratory marine wildlife during critical periods. Post-construction studies for all migratory species that may be affected by ocean energy facilities should be comparable to pre-construction studies to allow for direct comparisons of results. Post-construction studies should determine whether migratory species continue to use the project area with the same frequency as before construction of the project, whether the community structure of various taxa has changed (and if so, how), and whether the project appears to be causing negative (or positive) impacts to migratory species that continue to use the project area for feeding, movement, cover, or breeding. The effects of noise and the electromagnetic field generated by undersea cables on marine migratory species is an important consideration for post-construction studies.

Studies on the impacts of mitigation measures such as VLH and possibilities to mitigate impacts on intertidal habitats are essential.

6.5 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidelines; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

1) ACCOBAMS-MOP5/2013/Doc23. Implementation of underwater noise mitigation measures by industries: operational and economic constraints. (under preparation)
2) ACCOBAMS-MOP5/2013/Doc24. Methodological guide: Guidance on Underwater Noise Mitigation Measures (under preparation).

3) http://www.accobams.org/index.php?option=com_content&view=article&id=1164%3Amop5-working-documents-and-resolutions&catid=34&Itemid=65
4) [USDOE] United States Department of Energy. 2009. Ocean Energy Technology Overview.
5) [USDOI] United States Department of the Interior. 2007. Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf. Volume II, Chapter 5.
6) UNESCO Intergovernental Oceangraphic Commission. 2014. http://ioc-unesco.org/index.php?option=com_content&view=article&id=362&Itemid=100036
7) POSTNOTE number 435, 2013. Environmental impact of tidal energy barrages. House of Parliament, Parliamentary office of science & technology.

6.6 Literature

AECOM. 2012. Marine Renewable Energy: Background Report to Support a Strategic Environmental Assessment (SEA) for the Cape Breton Coastal Region, inclusive of the Bras d'Or Lakes. Prepared by AECOM for the Nova Scotia Department of Energy.

Boehlert, G. W., G. R. McMurray, and C. E. Tortorici (eds.). 2008. Ecological effects of wave energy in the Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-92.

[OEER] Offshore Energy Environmental Research. 2008. Fundy Tidal Energy Strategic Environmental Assessment: Final Report. Prepared by the OEER Association for the Nova Scotia Department of Energy.

[ORPC] Ocean Renewable Power Company. 2013. Cobscook Bay Tidal Energy Project 2012 Environmental Monitoring Report Final Draft. FERC Project No. P012711-005. Accessed online at: http://www.orpc.co/permitting_doc/environmental report_Mar2013.pdf

[USDOI] United States Department of the Interior. 2007. Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf. Volume II, Chapter 5.

Witt, M. J., E. V. Sheehan, S. Bearhop, A. C. Broderick, D. C. Conley, S. P. Cotterell, E. Crow, W. J. Grecian, C. Halsband, D. J. Hodgson, P. Hosegood, R. Inger, P. I. Miller, D. W. Sims, R. C. Thompson, K. Vanstaen. S. C. Votier, M. J. Attrill, and B. J. Godley. 2011. Assessing wave energy effect on biodiversity: the Wave Hub experience. Philosophical Transactions of the Royal Society A 370:502-529.

7 Solar energy

7.1 Main impacts

Main impacts of Concentrated Solar Power (CSP) are direct mortality or disturbance of migratory species. The main impact of Photovoltaic solar power (solar panels) is habitat loss. The main impacts of solar developments on migratory species are summarised below. There are no distinct differences in impacts between construction, decommissioning and operation phases. For a detailed description of the impacts of solar energy developments on migratory species we refer to the review of Van der Winden *et al*. (2014).

Concentrated Solar Power

- Loss of habitat of birds, mammals and insects, can be large-scale in some cases.
- Mortality of birds, mammals and insects through collision following attraction and incineration.
- Habitat degradation / fragmentation for birds, mammals and insects, such as lowered water availability.
- Disturbance / displacement of birds, mammals and insects through attraction to unsuitable habitats.

Photovoltaic solar

- Habitat loss for birds, mammals and insects, can be large-scale in some cases.
- Habitat degradation / fragmentation for birds, mammals and insects, such as lowered water availability.

For the purpose of sourcing and formulating guidelines on best practice for the environmentally sensitive development of solar energy projects, it has been assumed that it will occur in a terrestrial setting and that lake, waterway and marine or ocean habitats will not be where most solar energy development is located.

7.2 Legislation, policy and SEA and EIA procedures

For a general description of legislation, policy and the importance of and guidelines for Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) we refer to paragraph 2.2. The following paragraph describes relevant instruments and strategies that are specific to solar energy developments.

Legislation and policy

In Europe, the Habitats and Birds Directives provide guidelines for the protection of biodiversity. Article 6 of the Habitats Directive sets out a series of guidelines that must be applied to plans and projects that are likely to have a significant effect on a Natura 2000 site. For solar energy developments, the implementation of article 6 of the Habitats Directive includes the performance of Appropriate Assessments for development projects that may potentially lead to significant effects on the integrity of Special Areas of Conservation (SACs), Special Protection Areas (SPAs) or Ramsar sites, many of which include key migratory wildlife habitats.

Development and deployment of solar energy technology in the Western Hemisphere is currently concentrated primarily in the United States and Germany with other large-scale industrial plants in Spain and Morocco. Other nations have relatively little solar energy potential, are currently focused on electricity generation based on fossil fuels, or rely on other forms of renewable energy (such as hydropower). Several U.S. States have established minimum percentage requirements for solar energy generation and offer financing, tax incentives, and loans for the development of this resource. At the national level, the U.S. Departments of Energy and the Interior have several policy programmes designed to encourage the deployment of solar energy. The Western Solar Plan (discussed in detail below) integrates strategic planning for solar energy development in the south-western US, and the SunShot Initiative aims to make solar energy cost-competitive with fossil fuel-based energy by 2020. With regard to migratory species and their habitats, the Western Solar Plan identifies the need to consider these issues when developing and siting future solar energy facilities.

Strategic Environmental Assessments (SEA)

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. SEAs should be conducted in the planning stage to determine appropriate sites for solar energy developments. The United States Department of the Interior has issued a Draft Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development (2010) which outlines the general impacts and environmental concerns, including impacts to migratory wildlife, from solar energy development in the south-western United States. The principles outlined in the draft PEIS can be applied generally to any future large-scale solar energy development.

A good example of a strategic environmental assessment for the deployment of solar energy projects has been undertaken for the south-western United States of America. This assessment, termed a Programmatic Environmental Impact Statement (PEIS) was prepared by the U.S. Department of the Interior, the U.S. Bureau of Land Management (BLM) and the U.S. Department of Energy (DoE). It aims to provide guidance on the development of utility scale solar energy projects on public land in six key Sunshine States in the southwestern United States. It provides guidance on where solar energy development can occur on public land where they will not compromise other resource uses. It is assumed that solar energy development is a ‘single use’ and that it will largely exclude alternative uses. It identifies a series of Solar Energy Zones in which government will prioritize and facilitate the development of utility-scale solar energy developments. At least 30 utility-scale solar energy projects have been approved in the region in the past four years, with an additional 70 pending project applications.

Of relevance to the protection of migratory species and their habitats, the areas below are explicitly stated as exclusion areas for solar energy development. **Box 7.1** provides a listing of all the exclusion zones. It is significant that many of these exclusions rely on legal protections for habitats and species or groups of species (*e.g.* threatened species) that rest in other legislation. The excluded areas include (but are not limited to):

Box 7.1 Examples of exclusion zones for solar power planning US

- All Areas of Critical Environmental Concern (ACECs) identified in applicable land use plans (including Desert Wildlife Management Areas (DWMAs) in the California Desert District planning area).
- All designated and proposed critical habitat areas for species protected under the Endangered Species Act (ESA) of 1973 (as amended) as identified in respective recovery plans (http://ecos.fws.gov/tess_public/ TESSWebpageRecovery?sort=1).
- All areas where the BLM has made a commitment to state agency partners and other entities to manage sensitive species habitat, including but not limited to sage grouse core areas, nesting habitat, and winter habitat; Mohave ground squirrel habitat; flat-tailed horned lizard habitat; and fringe-toed lizard habitat.
- Greater sage-grouse habitat (currently occupied, brooding, and winter habitat) as identified by the BLM in California, Nevada, and Utah, and Gunnison's sage-grouse habitat (currently occupied, brooding, and winter habitat) as identified by the BLM in Utah.[c]
- In California, lands classified as Class C in the California Desert Conservation Area (CDCA) planning area.
- All Desert Tortoise translocation sites identified in applicable land use plans, project-level mitigation plans or Biological Opinions.
- All Big Game Migratory Corridors identified in applicable land use plans.
- All Big Game Winter Ranges identified in applicable land use plans.
- Research Natural Areas identified in applicable land use plans.
- Wild, Scenic, and Recreational Rivers designated by Congress, including any associated corridor or lands identified for protection through an applicable river corridor plan.
- Segments of rivers determined to be eligible or suitable for Wild or Scenic River status identified in applicable land use plans, including any associated corridor or lands identified for protection through an applicable land use plan.
- Old Growth Forest identified in applicable land use plans.
- In California, BLM-administered lands proposed for transfer to the National Park Service with the concurrence of the BLM.

<u>Environmental Impact Assessment (EIA)</u>

An Environmental Impact Assessment (EIA) is necessary for all potential solar developments to determine the risk the development may pose to the environment. For migratory species the EIA will consider all migratory species that have the potential to occur in the region and assess how significant an impact could be on the species population and its associated habitat. EIAs inform developers of effective and efficient ways to detect and avoid environmental impacts.

The United States of America again provides some excellent examples of comprehensive EIAs of utility-scale solar energy facilities. Site-specific EIAs should also be completed for proposed solar projects to determine the existing environmental conditions, expected project impacts, and recommended mitigation measures that apply specifically to the proposed project. Good examples include:

- Crescent Dunes, Nevada; and
- Genesis Solar Energy Project, California

7.3 Best practice of mitigation

Planning and siting

The following are the major measures taken to avoid impacts on migratory species during the planning stage of a solar energy development project. These measures are equally applicable to solar energy development projects.

- Site selection is the key to minimizing impacts
- Consult any applicable strategic environmental assessments and ecological values mapping to identify areas where solar developments are appropriate
- Carry out site-specific EIA including appropriate surveys for migratory wildlife
- Review other existing information on species and habitats in the study area.
- Contact appropriate agencies early in the planning process to identify potential migratory species that may be present in the study area
- Avoid legally protected areas (*e.g.* Ramsar sites, sites of national or sub-national value), and other sensitive sites such as wetlands, significant bird and bat roosts and significant wildlife breeding concentrations or migratory gathering sites, and key bottleneck sites.
- Design the development to avoid or minimize impacts to aquatic habitats, such as prevent leaching into nearby watercourses and re-designing drainage from the site.
- Develop solar energy technology on lands of lower conservation value to reduce development impacts on areas of higher conservation value
- Avoid surface water or groundwater withdrawals that affect sensitive habitats and habitats occupied by threatened or migratory species. The capability of local surface water or groundwater supplies to provide adequate water for cooling, if required, should be considered early in project siting and design.
- Solar energy facilities should not be located near water sources that attract migratory birds.
- Locate tall structures to avoid structures in important flight paths of birds and bats
- Investigate whether habitat management at the site level could provide benefits for birds and biodiversity
- Engage with governments, utility companies, consultants and conservation organisations and other stakeholders to ensure that the latest information is available and utilised along with guidelines given in this report.
- Use alternative types of solar energy technology such as parabolic troughs, dish engines, and photovoltaic systems instead of using a central tower facility (Roeb *et al* 2011). Decrease the number of evaporation ponds or use alternative types of solar

energy technology that do not use evaporation ponds. If evaporation ponds are required based on the type of solar facility, those ponds should be fenced and netted when possible (McCrary *et al*. 1986, Solar PEIS 2010).

- When using a central tower solar facility, the occurrence and intensity of standby points should be kept to a minimum to decrease the occurrence of burning mortality to birds (McCrary *et al*. 1986).
- Develop solar energy technology closer to, as well as in, cities (*e.g.* on rooftops) and in areas that are already impacted (Marquis 2009).
- Avoid developing solar energy technology in areas that are important migration corridors and flyways (Solar PEIS 2010).
- Use buried cables rather than overhead transmission lines to minimize habitat fragmentation and collision risks to birds.

In addition to planning for minimal impacts on migratory species and biodiversity in general, scope exists at solar farm sites to enhance habitat (see Box 7.2)

Box 7.2 Solar energy planning UK

An example of best practice guidance for planning solar energy development in the UK (BRE 2014) includes guidelines for preparing Biodiversity Management Plans (BMP's) for solar farms which have relevance to the protection of migratory non-marine wildlife and their habitats, as well as integrating enhancement of biodiversity into the planning and on-ground management of solar energy farms:

- "Identify key elements of biodiversity on site, including legally protected species, species and habitats of high conservation value… and designated areas in close proximity to the proposed site;
- identify any potential impacts arising from the site's development, and outline mitigations to address these;
- detail specific objectives for the site to benefit key elements of biodiversity and the habitat enhancements that are planned to achieve these;
- contribute to biodiversity in the wider landscape and local ecological networks by improving connectivity between existing habitats;
- identify species for planting and suitable sources of seed and plants;
- consider wider enhancements, such as nesting and rooting boxes;
- summarize a management regime for habitats for the entire life of the site;
- provide a plan for monitoring the site; and adapting management as appropriate to the findings of this monitoring;
- set out how the site will be decommissioned."

Mitigation

Construction and decommissioning

The following mitigation measures can be adapted to solar developments to minimize impacts to migratory species.

- Time construction to avoid sensitive periods (*e.g*., during the breeding season)
- Hedgerows between sections may reduce collision risks to waterfowl.

Operation

Concentrated Solar Power

Reduction of bird mortality - The following mitigation measures can be adapted to solar developments (Concentrated Solar Power) to minimize impacts to migratory bird species.

- Time maintenance operations to avoid sensitive periods
- Minimize lighting to what is needed for safety and security objectives. Turn off all unnecessary lighting at night to limit attracting migratory birds
- Use fencing, netting and wire grids to ensure evaporation ponds are not accessible to birds and other fauna. This is to reduce the possibility of a) attraction b) drowning c) poisoning
- Avian deterrence techniques, including: facility habitat management; prey control; anti-perching technology; nest-proofing; netting or other enclosures; scaring or chasing through the use of trained dogs or raptors; and radar and long-range focused bio-acoustic or visual deterrence.

The Crescent Dunes and Genesis solar projects in Nevada, USA and California, USA (CSP) respectively provide excellent examples of proposals for monitoring and mitigating the impacts of utility-scale solar energy projects on biodiversity. It is noteworthy that these measures include compensatory or offset measures that are both direct (habitat protection) and indirect (research).

The former project's EIA contained a 'Wildlife Mitigation and Monitoring Plan' that includes measures to ensure construction occurs outside the migratory bird nesting season and that the cooling water evaporation ponds are managed to deter use by birds. The plan also includes measures to mitigate and compensate for impacts on non-migratory and threatened fauna species. Measures stated include, for example:

- Anti-perching devices will be installed around the edge of ponds to prevent birds from accessing the water for drinking.
- Fencing will be used to discourage terrestrial wildlife, including small mammals, amphibians, and reptiles from accessing the ponds.
- At the end of each workday, excavation areas that may trap wildlife should be inspected for wildlife before backfilling. If backfilling is not feasible, all excavations shall be sloped at the ends to provide wildlife escape ramps or covered to completely prevent wildlife access.

For full details see:
http://www.blm.gov/pgdata/etc/medialib/blm/nv/field_offices/battle_mountain_field/blm_information/nepa/crescent_dunes_solar.Par.86958.File.dat/Appendix%20E.pdf

The conditions of certification for the Genesis plant represent current practice and are comprehensive in their coverage of flora, fauna and habitat impacts of the proposed solar plant. Measures stated include, for example:

- Limit disturbance areas through marking with flags and restrict activities to within these areas.
- Avoid trapping tortoises and other wildlife in trenches, pipes or culverts. To aid this, trenches will be back filled at the end of each day and the use of fences.

For full details see:
http://www.blm.gov/pgdata/*etc*/medialib/blm/ca/pdf/palmsprings/genesis.Par.19404.File.dat/Vol2_Genesis%20PA-FEIS_Apdx-G-Certification.pdf

7.4 Pre-construction assessment and pre- and post-construction monitoring

Monitoring is an essential component for assessing and managing biodiversity at solar developments. Pre-construction assessment programs should be designed to identify key indicators and establish baseline conditions for migratory species and their habitats. The monitoring results must be collected in a way that they can be measured and compared consistently over time to determine if mitigation measures have been effective. Monitoring at solar developments focuses on biodiversity including species richness and abundance of birds and reptiles, health of grasslands and maintenance of any plantings or habitat restoration works undertaken by the project. Monitoring should be performed before and after construction of the solar development in a comparable way. An adaptive management approach should be adopted whereby the results of monitoring inform the continuing management of the site.

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

<u>Pre-construction assessment and monitoring / Baseline study</u>
An important aspect of the pre-construction monitoring programme is determining the biological risks associated with the proposed solar development and undertaking an EIA. The EIA will identify risks and ways to mitigate the risks. Pre-construction monitoring will involve recording the species richness and abundance at the study area. Threatened and migratory species at the study area should be monitored in all stages of the cycle of the targeted species. Pre-construction monitoring should be undertaken for a sufficient period to gather information on all relevant periods a migratory species is present at the affected site, and take account of natural variability to the extent practicable.

<u>Post-construction monitoring</u>

Post-construction monitoring should continue for a period sufficient to establish whether a significant impact has occurred to affected migratory species. It must include the same methods, sites and timing of sampling as the pre-construction monitoring. Any mortality or injury of a migratory species at a solar development should be recorded and reported at all times. Where possible, a national program, under the auspices of a national body, such as an industry association or government body, should assemble data on the impacts of solar energy facilities on migratory fauna and publish it each year.

7.5 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidelines; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

As there are a limited number of utility-scale solar energy developments, guidelines on mitigating and managing impacts on migratory wildlife are also limited. A good starting point is:

Patton, T., L. Almer, H. Hartmann, and K.P. Smith, 2013, *An Overview of Potential Environmental, Cultural, and Socioeconomic Impacts and Mitigation Measures for Utility-Scale Solar Development*, ANL/EVS/R-13/5, prepared by Environmental Science Division, Argonne National Laboratory, Argonne, IL, June. Argonne National Laboratory, Chicago, USA.

Information on how to integrate biodiversity conservation outcomes into solar energy projects can be found at:

Birdlife International n.d. Birds and Solar Energy within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Solar Energy Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents

BRE 2014. Biodiversity guidance for solar developments. Eds G E Parker and L Greene. BRE National Solar Centre.

Gough, P., P. Philipsen, P.P. Schollema & H. Wanningen, 2012. From sea to source; International guidance for the restoration of fish migration highways.

The previously mentioned strategic environmental assessment and mitigation plans and conditions of certification from the south-western United States are also highly informative.

7.6 Literature

Marquis, A.L. 2009. "Solar Rush: California's Solar Boom Threatens the Very Places it's Meant to Protect". National Parks, Winter, 16-19.

McCrary, M.D., McKernan, R.L., Schreiber, R.W., Wagner, W.D. & Sciarotta, T.C. 1986. Avian mortality at a solar energy power plant. Journal of Field Ornithology 57: 135-141.

Pearce-Higgins, J.W. & Green, R.E. 2014. Birds and Climate Change: Impacts and Conservation Responses. Cambridge University Press, Cambridge.

Roeb, M., Säck, J.P., Rietbrock, P., Prahl, C., Schreiber, H., Neises, M., de Oliveira, L., Graf, D., Ebert, M., Reinalter,W., Meyer-Gr¨unefeldt,M., Sattler, C., Lopez, A., Vidal, A., Elsberg, A., Stobbe, P., Jones, D., Steele, A., Lorentzou, S., Pagkoura, C., Zygogianni, A., Agrafiotis, C., & Konstandopoulos, A. (2011). Test operation of a 100 kw pilot plant for solar hydrogen production from water on a solar tower. Solar Energy, 85, 634-644.

8 Wind energy

8.1 Main impacts

The potential impacts of wind farms on ecological systems include habitat loss through disturbance or displacement, barrier effects and collision-related mortality. Underwater sounds during offshore wind farm construction and electromagnetic fields of underwater cables have been noted as potential negative factors for marine life. The main impacts of wind farms on migratory species are summarized below for both the phase of construction and/or decommissioning and the operational phase. For a detailed description of the impacts of wind energy developments on migratory species we refer to the review document (van der Winden *et al.* 2014).

Construction and decommissioning phase

- Habitat loss for birds, bats, terrestrial mammals, fish, squid and crustaceans.
- Habitat degradation / fragmentation for birds, bats, fish and squid, marine mammals.
- Disturbance / displacement of birds, bats, marine mammals, terrestrial mammals, fish, squid and crustaceans.
- Physiological effects on marine mammals, fish and squid.
- Mortality of marine mammals, fish and crustaceans.
- Habitat gain for fish, squid and crustaceans, marine mammals

Operational phase

- Mortality of birds and bats.
- Disturbance / displacement of birds, (bats), marine mammals and fish.
- Changes in community structure of fish and crustaceans.
- Physiological effects on fish and crustaceans.

The effects of transmission and/or transportation of the generated energy are not incorporated in the above enumeration, but are discussed in chapter 2.

8.2 Legislation, policy and SEA and EIA procedures

For a general description of legislation, policy and the importance of and guidelines for Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) we refer to paragraph 2.2. The following paragraph describes relevant instruments and strategies that are specific for wind energy developments.

Legislation and policy

In Europe, the Habitats and Birds Directives provide guidelines for the protection of biodiversity. Article 6 of the Habitats Directive sets out a series of guidelines that must be applied to plans and projects that are likely to have a significant effect on a Natura 2000 site. For wind energy developments, the implementation of article 6 of the Habitats Directive including the performance of Appropriate Assessments is described in detail in:

Guidance Document, Wind energy developments and Natura 2000 (European Union 2011).

Legislation and policy specifically related to marine life

National and international guidelines and regulations exist for monitoring and mitigation of the effects of wind farms on marine mammals. Recommendations, guidelines and regulations with relevance to effects on the environment of underwater noise and/or offshore wind farms, have been prepared by many international forums, such as the European Commission, the U.S. Marine Mammal Commission, OSPAR, UNCLOS, CMS, ASCOBANS and the IWC. They are relevant given that they can, are, or should be taken up at the national level. International recommendations, guidelines and regulations include the EIA Directive, the European Habitats Directive, the European Integrated Maritime Policy, the Marine Strategy Framework Directive, and the Convention on Migratory Species (CMS) and daughter agreements such as the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS). For a description of the relevance of these to marine mammals in relation to offshore wind farms we refer to ICES (2010).

ICES (2010) stated that there were important differences in national guidelines on the mitigation of effects of offshore wind farms. They did however provide examples of guidelines in some countries for preventing and/or mitigating negative effects on marine mammals in the framework of the construction of offshore wind-farms (see table 3 in ICES 2010).

Legislation for (offshore) wind farms in the USA

Future offshore wind energy facilities in U.S. federal waters are regulated by the Bureau of Ocean Energy Management (BOEM) in conjunction with several other agencies. Future offshore wind developments in the United States must comply with various environmental laws designed to protect wildlife, including migratory species, and their habitats. These include:

- The National Environmental Policy Act of 1969 – requires a comprehensive analysis of potential impacts to the environment from any project that involves a major review by the federal government. This analysis must include an analysis of alternative scenarios to the proposed development and offer a monitoring and mitigation strategy when natural resources are expected to be impacted.
- The Endangered Species Act of 1973 – any project that may result in negative impacts to species listed under the Endangered Species Act (ESA) must receive approval from the U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS).
- The Marine Mammals Protection Act of 1972 – provides for the protection of all marine mammals – regardless of other conservation status – including cetaceans, pinnipeds, and the polar bear (*Ursus maritimus*). Offshore wind developers must consider the species potentially affected by their development and offer mitigation measures, monitoring, and reporting.

- The Magnuson-Stevens Fishery Convention and Management Act – requires the designation and protection of Essential Fish Habitats (EFH) for federally managed fish species. As part of the environmental assessment for proposed offshore wind facilities, an EFH assessment must be complete and submitted to NMFS for consultation.
- The National Marine Sanctuaries Act – provides for the creation and protection of National Marine Sanctuaries to preserve special marine resources. Offshore wind projects may not be built in any designated marine sanctuaries, and the potential effects to any nearby sanctuaries must be reviewed during the environmental assessment of offshore wind projects.

Onshore wind projects are also subject to a series of federal laws, including some of those listed above, as well as State and local regulations. Offshore wind projects in State waters (less than 3 nautical miles from land) are also subject to State regulations.

Strategic Environmental Assessments (SEA)

A Strategic Environmental Assessment (SEA) enables a framework to be set to identify the high risk areas so that developers are aware that there will be greater challenges in terms of environmental assessments and mitigation, and greater risk that consent will be refused. The most effective way to detect and avoid severe environmental impacts of wind energy developments is to perform SEAs on large spatial scales. SEAs enable strategic planning and siting of wind energy developments in areas with least environmental and social impact and largest economic benefit. Some good practice examples of strategic wind farm planning are described in Box 8.1. According to the Directive 2001/42/EC, national or international plans and programmes within the European Union Member States with likely significant environmental impacts shall be subject to an SEA; this includes large-scale wind energy development.

Box 8.1 Examples of strategic wind farm planning

Scotland: Scottish Natural Heritage has adopted a strategic locational guidance note for onshore wind farms, which includes a series of sensitivity maps. Altogether five maps have been developed, of which two describe sensitivity associated with landscape and recreation interests and two describe sensitivity arising from biodiversity and earth science interests. The final map combines these sensitivities into three broad zones representing three relative levels of opportunities and constraints. Overall the maps provide a broad overview of where there is likely to be greatest scope for wind farm development and where there are the most significant constraints in natural heritage terms. (Summary of the text in: Guidance Document, Wind energy developments and Natura 2000, European Union 2011). See also:
http://www.snh.gov.uk/planning-and-development/renewable-energy/onshore-wind.

Drôme Region, France: In 2005, the authorities of the Drôme *département* in France decided to develop a wind energy plan for the entire region. Detailed zonation maps were prepared in close consultation and dialogue with all interest groups. Each one identified different areas of high, medium or low potential in term of wind resources, relevant public utilities and access to grid connections. Based on wildlife sensitivity maps for specific species, a synthesis map was prepared to demarcate areas of particular environmental sensitivity. These detailed maps are intended to provide an early warning system of potential conflicts with these important species so that wind farms can be planned in function of this knowledge. (Summary of the text in: Guidance Document, Wind energy developments and Natura 2000, European Union 2011). See also: http://www.drome.equipement.gouv.fr/rubrique.php3?id_rubrique=146.

Offshore wind farms Denmark: Within the framework of a long-term national energy policy, in Denmark 23 offshore wind farm locations (within seven larger areas) were assessed. Locations have been selected within the framework of strategic planning approach, taking into account *e.g.* wind conditions, nature values, visibility and grid connections. (Summary of the text in: Guidance Document, Wind energy developments and Natura 2000, European Union 2011). See also: http://ec.europa.eu/ourcoast/download.cfm?fileID=983

The Netherlands: The Dutch Government strives to concentrate large-scale onshore wind energy developments in those areas that are 'most appropriate'. Therefore the Dutch Government developed a vision on onshore wind energy, which was adopted in March 2014. In total 11 areas in the Netherlands are designated for large-scale wind energy developments. The impact of wind energy on the natural environment was one of the criteria used to identify the 'most appropriate' areas for large-scale wind energy. See also:
http://www.rijksoverheid.nl/onderwerpen/duurzame-energie/nieuws/2014/03/31/kabinet-volgt-provincies-in-aanwijzing-11-gebieden-voor-windenergie-op-land.html.

Offshore wind farms in North and South America: There are currently no significant utility-scale offshore wind energy facilities anywhere in the waters off North or South America; however, several proposals for developing such facilities are pending and work to support these proposals is underway. The United States has begun the process of leasing blocks of the Outer Continental Shelf to wind power developers within the Exclusive Economic Zone of the United States in the northwest Atlantic Ocean. A strategic plan developed by the U.S. Department of Energy was released in 2011 to support the potential for offshore wind development in that country. The *National Offshore Wind Strategy* is meant to guide the actions of regulators to promote offshore wind development in a responsible manner. The report also acknowledges the shortage of available information on the impacts of siting and operation of an offshore wind energy facility may impact environmental resources, including migratory species, in U.S. waters. (United States Department of Energy 2011).

The Rift Valley / Red Sea: The Soaring Bird Sensitivity Map tool (by BirdLife) has been designed to provide developers, planning authorities and other interested stakeholders access to information on the distribution of soaring bird species along the Rift Valley / Red Sea flyway. This information can help to inform decisions on the safe siting of new developments, such as wind farms, ensuring that negative impacts on this important migration route are minimised (tinyurl.com/MSBmap).

South Africa: BirdLife South Africa, the Endangered WildLife Trust as well as a number of bird specialists developed an Avian Wind Farm Sensitivity Map for South Africa. The purpose of the map is to indicate localities in South Africa that contain species that are believed to be sensitive to wind farm developments. Care should be taken when developing wind farms in these areas.
(http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy/wind-farm-map)

Environmental Impact Assessment (EIA)

To determine the impacts of specific wind energy plans or projects on the natural environment, performance of an Environmental Impact Assessment (EIA) is crucial. (See for instance: Bowyer *et al.* 2009, European Union 2011, Ledec *et al.* 2011, Gove *et al*. 2013). In the context of migratory species, EIAs for wind energy developments should include all potentially affected taxa. Specifically the EIA should focus on the effects on birds, bats and marine life (offshore), as these species groups are most affected by the construction and/or operation of wind farms. For both offshore and onshore wind farms the possible detrimental effects on habitats and routes of migratory species should also be considered. A detailed description of Environmental Impact Assessment for Wind Farm Developments is given by UNDP-CEDRO (2011) and Gove *et al*. (2013). For specific guidelines on pre-construction monitoring, which is necessary to support EIAs, we refer to §8.4.

8.3 Best practice of planning and mitigation

8.3.1 Planning

<u>Siting</u>
The most effective way to avoid adverse effects of wind energy facilities on migratory species of all taxa is to plan wind energy away from habitats of rare species, their main migration routes and key sites along flyways. Key sites include *e.g.* migratory bottlenecks, wetlands, coastal areas and mountain ridges. On a local scale attraction of collision prone species to the wind farm area should be avoided by carefully considering the design of the surrounding area including land use.

<u>Wind farm configuration</u>
The extent of adverse effects of wind energy facilities on birds partly depends on the configuration of the wind farm. A larger space in between turbines lowers the collision rate of birds and may also be experienced as less threatening as a barrier by local foraging or breeding birds (Data from research on the effects of Offshore Wind Farm Egmond aan Zee, The Netherlands). To avoid barrier effects, long lines of turbines should be placed parallel to the main migration/flight route and corridors can be planned in between large clusters of turbines, to provide safe flight routes through the area. This will also lower the collision risk as it enhances the possibilities for birds to safely pass the wind farm.

<u>Turbine type</u>
The collision rate of local birds (short distance flights) decreases when the space underneath the rotor blades increases. In the operational phase, larger turbines seem to have a smaller disturbing effect on small ground-breeding birds than smaller turbines. Using solid turbine towers instead of lattice constructions avoids perching opportunities for birds of prey. For bats the information on the influence of turbine type (*e.g.* height, rotor area) on bat mortality is not conclusive. For marine life the underwater structure is most important. For certain foundation types pile driving is not needed, which avoids disturbance of marine life, *e.g.* marine mammals and fish. However, the choice for a specific type of foundation largely depends on the characteristics of the seabed and water depth. Therefore, pile driving cannot always be avoided.

References describing mitigating measures concerning siting, configuration or turbine type: Hötker *et al.* (2006), Wilhelmsson *et al.* (2010), BirdLife Europe (2011), U.S. Fish and Wildlife Service (2012).

8.3.2 Mitigation

Murphy (2010) assessed the marine renewables energy industry in relation to marine mammals synthesising the work carried out by the ICES working group on marine mammal ecology. For offshore wind turbines an overview is provided of sources of impact, relevant impact studies, research needs and mitigation measures during construction (including site surveying prior to construction), operation and decommissioning. Information extracted from this work is included in the following paragraphs.

<u>Construction and decommissioning</u>
Marine mammals (and other marine life affected by noise) - The ICES working group on marine mammal ecology identified the following mitigation measures for construction of offshore wind turbines in general: construction should occur during periods with low abundance and noise emissions from other sources (*e.g.* ships, boats) should be reduced (ICES 2010). Specific for pile driving they identified various mitigation measures including the detection of the presence of marine mammals using visual observers, the use of acoustic deterrent devices, using ramp up procedures, reducing radiated energy at relevant frequencies, limiting installation to periods with low marine mammal abundance and identifying other technical possibilities to install the wind turbines (*e.g.* alternative constructions such as tripod, jacket or gravity foundations, floating or platforms and/or other methods than pile driving such as installation by a water jet or drilling). Decommissioning of offshore wind turbines is fundamentally similar to the removal of other types of offshore structures, such as oil and gas platforms. An option to avoid negative impacts could be to leave the structures in place (Wilhelmsson *et al.* 2010).

The effectiveness of some of these mitigation measures is discussed in several documents, such as:

- An assessment of the potential for acoustic deterrents to mitigate the impact on marine mammals of underwater noise arising from the construction of offshore wind farms was carried out by SMRU Ltd. in 2007.
- The development of noise mitigation measures in offshore wind farm construction by Koschinski & Lüdemann in 2013 covering bubble curtains, isolation casings, cofferdams, hydro sound dampers and acoustic improvements of the piling process (Koschinski & Lüdemann 2013).

<u>Operation</u>
For the operational phase mitigation generally focuses on the reduction of mortality of birds and bats, as this is the effect with the highest impact on ecological systems.

Reduction of bird mortality - The most effective measure is the temporary shutdown of turbines in high-risk periods, such as peaks in migration activity or foraging flights or situations with strong winds (from a specific direction). The timing of these high-risk periods differs between sites and largely depends on the landscape and geographical location of the wind farm. Guidance for a best practice approach for using this so-called ‘shutdown-on-demand’ is given in Collier & Poot (in prep.).

Additionally, several other mitigation strategies to reduce the collision rate for birds are discussed in literature. The effectiveness of these measures is, however, a matter of discussion and examples of actual application of these measures are limited. Some examples are:

- Increasing the visibility of wind turbines using contrasting patterns on the blades, or ultraviolet paint.
- Placing dummy turbines at the end of lines or edges to reduce collision victims under birds that try to avoid wind farms.
- Using scaring devices as deterrents to reduce flight intensity in a wind farm.
- Reduce the intensity of lights and maximize the interval between flashes to avoid attraction of birds to wind turbines.

See for instance: Hötker *et al* (2006), Drewitt & Langston (2006), Birdlife International n.d.

Reduction of bat mortality – Currently only one mitigation measure has demonstrated effective reductions of fatalities of bats. Targeted curtailment *i.e.* stopping or slowing down the rotor blades of a wind turbine during periods of high bat activity is the only known method that effectively limits bat mortality. Curtailment obviously reduces energy production and it is therefore essential to limit curtailment to those periods with high bat activity. Increasing the cut-in speed (the lowest wind speed at which the blades of a turbine will begin rotating) and changing the blade angles of turbines to reduce operations during periods of low wind speeds has been shown to reduce bat mortality by 44% – 93%, with ≤1% loss in total annual power output in this specific case. Arnett *et al*. (2013) suggests that cut-in speeds of between 1.5 – 3.0 m/s offer an ecologically and economically feasible approach. There are a few curtailment methods that are more precise: bat friendly curtailment algorithms developed in Germany (Behr *et al*. 2011) and the French system called Chirotech. See also Lagrange *et al.* (2012), Arnett *et al.* (2013).

Additionally, several other mitigation strategies to reduce the collision rate for bats are discussed in literature. The effectiveness of these measures is, however, a matter of discussion and examples of actual application of these measures are limited. Some examples are:

- Deter or scare away bats using ultrasound, light or radar.
- Adapt landscape features to influence the presence and activity of bats at the wind farm location.
- Lower the amount of insects attracted to wind turbines (and thereby possibly attraction of bats) by painting the turbines purple.

See for instance: Nicholls & Racey (2009), Long *et al.* (2010), Arnett *et al.* (2011).

Limiting the impact of noise emission on marine mammals - Potential impacts on marine mammals during the operational phase may be minimized by the modification of turbines and foundations to reduce noise emission at relevant frequencies, carry out large maintenance operations in periods with the number of marine mammals in the area are low and select service vessels based on minimal impact (ICES 2010).

8.4 Pre-construction assessment and pre- and post-construction monitoring

This paragraph focuses on pre-construction assessment and monitoring and post-construction assessment and monitoring of (habitats of) birds, bats and marine life, as wind energy developments generally pose a specific threat to these species groups. For a general description of the importance of and guidelines for pre- and post-construction monitoring we refer to chapter 2.

Pre-construction assessment and monitoring and post-construction monitoring are discussed separately in this paragraph, but in practice they are closely linked. Several guidelines documents prescribe the use of a Before-After-Control-Impact (BACI) approach for pre- and post-construction monitoring. This means that monitoring should be performed before and after construction in a comparable way and monitoring should be performed at the site in question as well as at one or more control areas.

Mortality of birds and bats through collisions with turbines is a key issue in assessing the effects of wind farm developments on migratory species. Besides assessing the potential number of collisions, usually through collision rate models (see below), it is important to place these in context of the potential effects at the population level. Several examples of how additional mortality on a population can be assessed are given in box 8.2.

Box 8.2 Assessing the effects of additional mortality at the population level

1% criterion in the Netherlands

In the framework of the Dutch nature legislation criteria have been developed for acceptable effects on wildlife. For mortality of wind turbines on birds and bats the 1% additional annual mortality criterion has been proposed in procedures and is currently accepted by law. Recently, this has applied to assessments for multiple planned wind farms. Poot *et al*. (2011) illustrated that this 1% level is far below the level of mortality needed to affect bird populations in the North Sea. The value of 1% derives from guidance with respect to the application of Article 9 of the Birds Directive[2] which specifies that “small numbers” in the context of Article 9 derogations are less than 1% of the overall annual mortality rate for the population in question

Population models

Potential Biological Removal

For more critically endangered species the Potential Biological Removal (PBR) approach can be used (Lebreton 2005, Niel & Lebreton 2005, Dillingham & Fletcher 2008).

<u>Pre-construction assessment and monitoring / Baseline study</u>

Birds – An important function of pre-construction monitoring is to determine the species at risk and gather information on which the prediction of the extent of the impact on birds can be based. Pre-construction monitoring should involve studies of the abundance, dispersal,

[2] Pages 60-65 of http://ec.europa.eu/environment/nature/conservation/wildbirds/hunting/guide_en.htm

activity and flight patterns of (sensitive) bird species. The monitoring generally includes studies of bird migration and surveys for breeding, staging and wintering birds. Methods that can be applied are visual and acoustic survey techniques as well as the use of automated systems like for instance radar or radio telemetry. Offshore surveys can be done by airplane, from a ship or from a platform in or nearby the wind farm area. The monitoring period should at least include all stages of the life cycle of the relevant species (breeding, wintering, migration), which generally means a minimum monitoring period of 12 months. To predict the number of collision victims for birds, the use of collision rate models is highly recommended. Information gathered during pre-construction monitoring should be used as input information for these models.

Bats – Also for bats the pre-construction monitoring should primarily point out the species at risk and landscape features used by bats. The monitoring should include activity surveys as well as roost surveys. The activity surveys should include all different functional stages (*e.g.* migration, foraging and dispersion of colonies). Many different methods can be applied and depending on the specific situation the most appropriate method should be selected. Examples of methods are surveys with hand held or automated bat detectors, radio tracking, trapping, night vision equipment (infrared or thermal camera's) and radar. Consideration should be given to the height at which surveys may need to be undertaken. Surveys are often carried out at ground level, but in many situations information on bat activity at rotor height is needed. Using site-specific opportunities, like for instance a tower or meteorological mast present at the wind farm area, bat detectors can be placed at height to gather this information.

Marine life – The baseline study or pre-construction monitoring should focus on the species and abundance of marine life (mammals, fish, squid and crustaceans) and the importance and function of the area for these species. Additionally also the migration patterns and timing of migration of *e.g.* marine mammals and fish should be determined. The baseline study should also determine whether the project area provides critical resources for migratory marine species.

With respect to baseline monitoring to be able to assess effects of offshore wind farms on marine mammals the ICES working group on marine mammal ecology advised (in paragraph 4.5):

- the establishment of means for efficient dissemination of results of common interest and making previous EIA reports and previously collected baseline data available for subsequent studies and assessments.
- to encourage multinational studies and encourage management decisions regarding offshore wind farms to be based on appropriate populations and/or management units for the relevant marine mammal species, irrespective of national borders.
- As the development of wind farms extends further offshore and into new waters, monitoring should be extended to include all commonly occurring marine mammal species and marine mammals species of particular concern.

- Geographical location of offshore wind farms should consider the distribution of marine mammals throughout the year, time of day and under typical weather and hydrographical conditions.
- to increase efforts to develop common measurement standards for both noise and marine mammal abundance.

Post-construction monitoring

Birds – Post-construction monitoring should be linked to pre-construction monitoring and the same type of surveys should be performed to obtain information on actual effects. Additionally bird mortality can be quantified using collision victim searches. These studies should also assess search efficiency and scavenging rates to be able to determine actual collision rates.

Bats – Also for bats the actual effects of the operation of the wind farm should be determined by linking the post-construction monitoring to the baseline study. Similar to birds, the actual collision rate can be determined based on collision victim surveys, including assessment of search efficiency and scavenging rates. For bats the direct impact due to the functioning of wind farms is not yet fully understood as in most cases the cause of collision is unknown. Therefore, also studies on the (foraging) behaviour of bats close to wind turbines are important.

Marine life – After construction of the wind farm monitoring should be linked to the baseline study so actual effects of the operation of the wind farm on marine life can be assessed. This means that also after construction the presence of marine life should be determined as well as the function of the area for the species present. Additionally, information on operational underwater noise generation can be gathered in combination with information on the behaviour of *e.g.* fish or marine mammals in a wide range around the wind farm. Finally, also the influence of the electromagnetic field generated by underwater cables can be assessed by linking post-construction distribution and abundance of species with data gathered before construction of the wind farm.

With respect to impact monitoring of offshore wind farms on marine mammals the ICES working group on marine mammal ecology advised (in paragraph 4.5):

- to increase the effort to characterize sources of underwater noise related to the construction and operation of offshore wind farms. As part of this, common standards for measurement and characterization of underwater noise should be developed (*e.g.* Southall *et al*., 2007, de Jong *et al*, 2010);
- to develop methods to assess cumulative effects on marine mammals of the underwater noise level caused by the simultaneous construction and operation at nearby sites;
- to step up research on the behaviour of marine mammals as a consequence of increased underwater noise levels, in particular how changes ultimately affect population parameters;
- to increase efforts to characterize fundamental properties of the auditory system of marine mammals and the way noise affects physiology and behaviour.

Guidelines

- For detailed guidelines on pre- and post-construction assessment and monitoring of birds in onshore wind farms we refer to: Jenkins *et al.* (2011).
- Guidelines on pre- and post-construction monitoring of birds in offshore situations can be found in: Fox *et al.* (2006).
- Guidelines for studies on search efficiency and scavenger removal are provided by: Smallwood (2007).
- Examples of papers describing collision rate models are: Tucker (1996), Troost (2008), Band (2012) and Smales *et al.* (2013).
- For detailed guidelines on pre- and post-construction monitoring of bats in both offshore and onshore wind farms we refer to: Rodrigues *et al.* (2008).
- Guidelines on pre-construction monitoring of bats in onshore wind farms are given by: Hundt *et al.* (2011).
- Detailed guidelines on pre- and post-construction monitoring of nocturnally active birds and bats in (onshore) wind farms is given by: Kunz *et al.* (2007).
- National guidelines on monitoring and mitigating effects of wind farms include for Germany: BSH (2007a; 2007b; 2008), for the UK: Cefas (2004), DEFRA (2005), JNCC (in consultation), and for the Netherlands: Prins *et al*. (2008).
- In 2009 SMRU Ltd carried out a strategic review of Offshore Wind Farm Monitoring Data Associated with FEPA Licence Conditions with respect to marine mammals. They reviewed marine mammal monitoring programmes carried out to assess effects of offshore wind farms in the UK and Denmark and provided recommendations for future monitoring (Cefas 2010).
- Legal requirements to carry out marine mammal monitoring vary between countries (see for example paragraph 8.2 legislation, policy and SEA and EIA procedures of this chapter and table 3 ICES 2010).

8.5 Summary of existing guidelines and tools

This paragraph provides a summary of recommended sources of information, tools and guidelines; this list is not intended to provide all available sources but instead the most recent, relevant, useful and acknowledged guidelines on the relevant topic.

Arnett, E.B., G.D. Johnson, W.P. Erickson & C.D. Hein, 2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. A report submitted to the National renewable Energy laboratory. Bat Conservation International. Austin, Texas, USA.

Arnett, E.b., C.D. Hein, M.R. Schirmacher, M. Baker, M.M.P. Huso & J.M. Szewczak, 2011. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Band, W., 2012. Using a collision risk model to assess bird collision risk for offshore wind farms. Guidance document. SOSS Crown Estate.

BirdLife Europe, 2011. Meeting Europe’s Renewable Energy Targets in Harmony with Nature (eds. Scrase I. and Gove B.). The RSPB, Sandy, UK.

BirdLife International 2014 The MSB Sensitivity Mapping http://migratorysoaringbirds.undp.birdlife.org/en/sensitivity-map

Birdlife International n.d. Birds and Wind Farms within the Rift Valley/ Red Sea Flyway. Migratory Soaring Birds Project. Wind Energy Guidance v.1. Developers & consultants. http://migratorysoaringbirds.undp.birdlife.org/en/documents

BMU Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Concept for the Protection of Harbour Porpoises from Sound Exposures during the Construction of Offshore Wind Farms in the German North Sea (Sound Protection Concept). Report in English.

Bowyer, C., D. Baldock, G. Tucker, C. Valsecchi, M. Lewis, P. Hjerp & S. Gantioler, 2009. positive planning for onshore wind. Expanding onshore wind energy capacity while conserving nature. A report by the Institute for European Environmental Policy commissioned by the Royal Society for the Protection of Birds.

BSH. 2007a. Standard - Design of offshore wind turbines. Federal Maritime and Hydrographic Agency (BSH).

BSH. 2007b. Standard - Investigations of the Impacts of Offshore Wind Turbines on the Marine Environment. Federal Maritime and Hydrographic Agency (BSH).

BSH. 2008. Standard – Ground investigations for offshore wind farms. Federal Maritime and Hydrographic Agency (BSH).

Cefas, 2010. Strategic review of offshore wind farm monitoring data associated with FEPA Licence Conditions. Project Code ME1117.

Cefas, 2004. Guidance note for environmental impact assessment in respect of FEPA and CPA requirements. Prepared on behalf of the Marine Consents and Environmental Unit (MCEU). Version 2, June 2004.

Collier, M.P. & M.J.M. Poot, in prep. Review and guidance on use of “shutdown-on-demand” for wind turbines to conserve migrating soaring birds in the Rift Valley/Red Sea Flyway. Report nr. 13-282. Bureau Waardenburg, Culemborg. Report prepared for BirdLife International, under the UNDP-Jordan/GEF Migratory Soaring Birds (MSB) project.

DEFRA, 2005. Nature conservation Guidance on Offshore Windfarm Development: a Guidance Note for Developers Undertaking Offshore Wind farm Developments. Prepared by Department of Environment, Food and Rural Affairs.

Dillingham P.W. & D. Fletcher 2008. Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relationship. Biol. Cons. 141:1738-1792.

Dolman, S.J. and Simmonds, M.P. 2010. Towards best environmental practice for cetacean conservation in developing Scotland’s marine renewable energy. Marine Policy, 34, 1021–1027.

Drewitt, A.L. & R.H.W. Langston, 2006. Assessing the impacts of wind farms on birds. Ibis 148: 29-42.

EUROBATS, 2013. Progress Report of the IWG in “Wind Turbines and Bat Populations”. Doc.EUROBATS.AC18.6. UNEP/EUROBATS Secretariat, Bonn.

EUROBATS, 2014. Report of the Intersessional Working Group on Wind Turbines and Bat Populations http://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/Doc_StC9_AC19_12_ReportIWG_WindTurbines%20incl_Annexes.pdf

European Union 2011, Guidance document, wind energy developments and Natura 2000. http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind-_farms.pdf

Fox, A.D., M. Desholm, J. Kahlert, T. K. christensen & I.K. Petersen, 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148: 129-144.

Gove, B., R.H.W. Langston, A. McCluskie, J.D. Pullan & I. Scrase. Wind farms and birds: an updated analysis of the effects of wind farms on birds, and best practice guidance on integrated planning and impact assessment. RSPB/BirdLife in the UK. Technical document T-PVS/Inf(2013)15 to Bern Convention Bureau Meeting, Strasbourg, 17 September 2013.

Hötker, H., K.-M. Thomsen & H. Köster, 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats. Facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut im NABU, Bergenhusen.

Hundt, L., K. Barlow, R. Crompton, R. Graves, S. Markham, J. Matthews, M. Oxford, P. Shepherd & S. Sowler, 2011. Bat surveys – good practice guidelines 2nd edition. Surveying for onshore wind farms. Bat Conservation Trust, London.

ICES. 2010. Report of the Working Group on Marine Mammal Ecology (WGMME), 12–15 April 2010, Horta, The Azores. ICES CM 2010/ACOM:24. 212 pp.

Jenkins, A.R., C.S. van Rooyen, J.J. Smallie, M.D. Anderson & H.A. Smit, 2011. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa. Produced by the Wildlife & Energy Programme of the Endangered Wildlife Trust & BirdLife South Africa.

de Jong, C. A. F., Ainslie, M. A., and Blacquiere, G. 2010. Measuring underwater sound: towards measurement standards and noise descriptors. TNO report TNO-DV 2009 C613. TNO.

Koschinski S. & Lüdemann K, 2013. Development of noise mitigation measures in offshore windfarm construction. Commissioned by the Federal Agency for Nature Conservation.

Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland & J.M. Szewczak, 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. The Journal of Wildlife Management 71: 2449-2486.

Lagrange H., E. Roussel, A.-L. Ughetto, F. Melki & C. Kerbirou (2012) Chirotech – Bilan de 3 années de régulation de parcs éoliens pour limiter la mortalité des chiroptéres. Rencontres nationales « chauves-souris » de la SFEPM (France). (cited in EUROBATS 2013).

Lebreton J.D. 2005. Dynamical and statistical models for exploited populations. Aust. N. Z. J. Stat 47(1): 49-63.

Ledec, G.C., K.W. Rapp & R.G. Aiello, 2011. Greening the wind. Environmental and social considerations for wind power development in Latin America and Beyond. Full Report. Energy Unit, Sustainable Development Department Latin America and Caribbean Region, The World Bank.

Long, C.V., J.A. Flint & P.A. Pepper, 2010. Insect attraction to wind turbines: Does colour play a role? European Journal of Wildlife Research 72: 323-331.

Murphy, S., 2010. Assessment of the marine renewables industry in relation to marine mammals: synthesis of work undertaken by the ICES Working Group on Marine Mammal Ecology (WGMME). http://iwc.int/private/downloads/4r0qft5f9vaccwg4ggk0wggws/Synthesis%20of%20work%20undertaken%20by%20the%20ICES%20WGMME%20on%20the%20marine%20renewables%20industry.pdf

Nicholls, B. & P.A. Racey, 2009. The aversive effect of electromagnetic radiation on foraging bats – a possible means of discouraging bats from approaching wind turbines. PLoS ONE 4: e6246.

Niel C. & J.D. Lebreton 2005. Using demographic invariants to detect overharvested bird populations form incomplete data. Conservation Biology 19(3): 826 – 835.

Poot, M.J.M., van Horssen, P.W., Collier, M.P., Lensink, R. & Dirksen, S. 2012. Cumulative Effects of Wind Farms in the Dutch North Sea on Bird Populations. Bureau Waardenburg Research Report 11-026, Culemborg, the Netherlands.

Prins, T.C., Twisk, F., Van den Heuvel-Greve, M.J., Troost, T.A. and Van Beek, J.K.L. 2008. Development of a framework for Appropriate Assessments of Dutch offshore wind farms. IMARES report Z4513.

Rodrigues, L., L. Bach, M.-J. Dubourg-Savage, J. Goodwin & C. Harbusch, 2008. Guidelines for consideration of bats in wind farm projects. EUROBATS Publication Series No. 3 (English version). UNEP/EUROBATS Secretariat, Bonn, Germany.

Smales, I., S. Muir, C. Meredith & R. Baird, 2013. A description of the Biosis model to assess risk of bird collisions with wind turbines. Wildlife Society Bulletin, 37(1), 59-65.

Smallwood, K.S., 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71(8): 2781-2791.

SMRU Ltd., 2007. Assessment of the potential for acoustic deterrents to mitigate the impact on marine mammals of underwater noise arising from the construction of offshore windfarms. Commissioned by COWRIE Ltd (project reference DETER-01-07).

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J., Gentry, R., Green, C.R., Kastak, C.R., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A., a nd Tyack, P.L. 2007. Marine Mammal Noise Exposure Criteria. Aquatic Mammals 33: 411–521.

Troost, T., 2008. Estimating the frequency of bird collisions with wind turbines at sea. Guideline for using the spreadsheet “Bird collisions Deltares v1-0.xls”. Deltares, Delft.

Tucker, V.A., 1996. A mathematical model of bird collisions with wind turbine rotors. Journal of Solar Energy Engineering 118, 253-262.

UNDP-CEDRO, 2011. Environmental Impact Assessment for wind farm developments 2012, a guideline report. Prepared by Biotope for the UNDP-CEDRO Project.

USDOE United States Department of Energy, 2011. A national offshore wind strategy: creating an offshore wind energy industry in the United States.

U.S. Fish and Wildlife Service, 2012. Land-based wind energy guidelines. U.S. Fish & Wildlife service.

Wilhelmsson, D., T. Malm, R. Thompson, J. Tchou, G. Sarantakos, N. McGormick, S. Luitjens, M. Gullström, J.K. Patterson Edwards, O. Amir & A. Dubi, 2010. Greening Blue Energy: Identifying and managing the biodiversity risks and opportunities of offshore renewable energy. Gland, Switzerland: IUCN.

Williams, D.R., Pople, R.G., Showler, D.A., Dicks, L.V., Child, M.F., zu Ermgassen, E.K.H.J. and Sutherland, W.J. (2012) Bird Conservation: Global evidence for the effects of interventions. Exeter, Pelagic Publishing.

van der Winden, J., F. van Vliet, C. Rein & B. Lane, 2014. Renewable Energy Technology Deployment and Migratory Species: an Overview. Report nr. 14-019. Bureau Waardenburg, Boere Conservation Consultancy, Brett Lane & Associates and ESS Group. Commissioned by International Renewable Energy Agency, Convention on Migratory Species, African-Eurasian Waterbird Agreement and Birdlife International, UNDP/GEF/Birdlife MSB project.

9 Recommendations

This chapter summarizes recommendations for actions and research related to minimizing the impacts of renewable energy technology developments on migratory species.

Migratory species in strategic planning
Conduct strategic planning of renewable energy technology developments on an international scale thereby taking into account migratory species to tackle the cumulative impacts of renewable energy technology developments on migratory species effectively. Most impacts on migratory species are related to inadequate planning and siting as well as scale. The cumulative assessment of impacts at population scale during the full life cycle (reproduction, migration, and non-reproduction phases) is currently a major conservation challenge. Cumulative impacts are expected to increase in future. International strategic assessment for renewable energy technology development is required to identify potential cumulative effects across borders. This assessment should consider the cumulative effects of multiple renewable energy technology deployments in conjunction with other renewable and non-renewable energy developments, to ensure that cumulative developments do not result in unexpected barriers or hazards. Renewable energy developments that potentially have significant negative impacts on migratory species should be avoided.

Development of sensitivity mapping tools
It is highly recommended that sensitivity mapping is further developed on an international scale. Sensitivity maps are useful tools to assist the strategic planning process of renewable energy technology developments. Sensitivity maps help visualize the relative sensitivity of areas throughout the migratory pathway, to inform the site selection process for future renewable energy developments. By using sensitivity mapping tools at an early strategic planning stage, high-risk areas with respect to migratory species can be identified (early warning) and the risks for these species can be avoided or substantially reduced by proper macro-siting. There are already good examples of sensitivity mapping tools.

Strengthen national and international SEA and EIA legislation and regulations
Strengthen national and international legislation and regulations regarding the impacts of renewable energy technology development and migratory species and migratory pathways. Use examples of good practice when developing specific renewable energy technology related legislation as described in this guidelines report.

Proper national SEA and EIA procedures should be implemented for renewable energy technology development. In particular for bioenergy, this is not straightforward, as changes in agricultural land use in general are not subject to spatial planning or environmental assessment.

Definition of impact criteria

Develop, propose and implement internationally accepted ecologically based impact criteria for the assessment of the effects including cumulative impacts of renewable energy technologies at migratory species population levels.

Project level environmental impact assessment

Follow existing international environmental guidelines, recommendations and criteria for the project-level environmental impact assessment development and utilization of renewable energy sources. Ensure that migratory species are considered within this process.

Implement measures to avoid and/or mitigate impacts

Avoid and/or mitigate impacts of renewable energy technologies on migratory species by implementing good practice guidance. Good practice includes proper design, siting, construction, operation and maintenance of renewable energy technology developments.

Adopt an adaptive management strategy in RET developments

Encourage the adoption of adaptive management strategies with continuous monitoring and scientific evaluation to reduce impact uncertainties and improve mitigation measures over time. Pre-construction assessment and post-construction monitoring are important to provide information for the planning decisions, both for already planned and future projects. As new RET projects enter the planning phase, site-specific and technology-specific studies will be required to best predict potential conflicts with migratory species in the area (pre-construction assessment) and to evaluate mitigation measures and predicted impacts afterwards (post-construction monitoring). The information can also be used for improvement of mitigation techniques for other renewable energy projects in future. Post-construction monitoring is now an obligatory standard for *e.g*. large wind farms and new power lines in northwest Europe and is essential to be able to maintain a sufficient level of knowledge. Monitoring studies on the effectiveness of mitigation should always be published (for example in the journal *Conservation Evidence*) to have the information widely available

Taskforce

Install a multi-stakeholder task force to facilitate the process of reconciling energy sector developments with the conservation of migratory species. The task force should promote that existing decisions and guidelines are implemented, any necessary new guidelines and action plans are elaborated, suitable responses to specific problems are recommended and put in place and gaps in knowledge are filled.

Further research

Migratory pathways

For all RET the primary gap in knowledge of (potential) impacts of RET development and migratory species lie in the detailed understanding of important areas for migratory species, including frequently used movement paths, areas with exceptional concentrations of migratory species, important breeding, feeding or resting grounds and narrow migration corridors. Many species' migration routes and habitat use patterns remain understudied and require further research. Detailed information in these areas will be imperative to the careful siting and design of renewable energy projects.

Impacts of RET development on migratory species

Besides understanding of migration routes, monitoring the environmental impacts during the life cycle of existing RET is needed to learn more about the impacts on migratory species. To date, very few attempts have been made to study impacts at the larger scale, such as population level or entire migration routes (*e.g*. intercontinental "flyways" for birds). Most such studies are theoretical rather than evidence-based. For all RET developments the long-term and population-level consequences of large-scale deployments need further research.

Effective mitigation measures

More research is needed on new innovative measures to avoid and/or mitigate impacts of RET on migratory species and the effectiveness of measures. So far, few mitigation measures are actually in place. Especially, there is a need for cost effective measures that can greatly reduce risks to migratory species with minimal impact on RET operations.

Increased knowledge on impacts of RET on migratory species and effective mitigation measures will better inform decision making in support of the prospective accelerated deployment of renewable energy done in a way that is reconcilable to the protection of migratory species. At the project level the improved knowledge should help streamline environmental impact assessments of renewable energy projects.